

Design of a Simple 3-Lead ECG Acquisition System Based on MSP430F149

Peng Wang* and Zhigang Lv

School of Electronic and Information Engineering Xi'an Technological University, 710032, Xi'an China

Abstract. Cardiovascular disease is one of the major diseases which threaten human health, and ECG is the primary means of diagnosis of cardiovascular disease. This paper mainly introduces the design procedure of a simple 3-lead ECG acquisition system based on MSP430F149, introduces the structure and function of the device, finally introduces the function of each module, circuit design and the program design. The device completes the process of data acquisition using the ultra-low power microcontroller MSP430F149, and collects ECG signal to A/D sampling and conversion. It sends the ECG information to the patient phone by the Bluetooth module. This paper explains the software design process in detail, and the realization of a hardware design and optimization. The main content of software design is the data collection and the serial communication module. The software design includes the main program, timer-A interrupt, button interrupted, A/D converter, and serial communication program. This design can create a new device of 3-Lead ECG system.

Keywords: ECG; Data Acquisition; Bluetooth; MSP430F149

1. Introduction

Cardiovascular disease is one of the major diseases which threaten human health; ECG is the primary means of diagnosis of cardiovascular disease. Conventional ECG monitor is expensive, and cable transmission is not convenient, it can't meet consumer demand of most patients. This paper examines the simple 3-lead ECG acquisition system which transmits the ECG information to the patient phone by the wireless communication ways, and sends the patient information to the community hospital diagnostic system via mobile phone. The device is easy to use, has low power consumption and it can meet the needs of continuous work. It has low price, can be purchased from the general population, and it's the best choice for applications of home applications, community medical services.

This paper introduces the design procedure of the hardware and software using MSP430F149. The software design includes the main program, timer A interrupt, button interrupted, A/D converter, and serial communication program^[1].

2. System Components

It introduces each components of the system in detail, including structure model of the hardware and software design. The simple 3-lead ECG system collects signal by the sensor, the signal is amplified and filter, then sampled and converted by MSP430F149 internal A/D module. The converted data is sent to the PC by Bluetooth module, the PC analysis and process the collected signal. The diagram of system components is shown as figure 1.

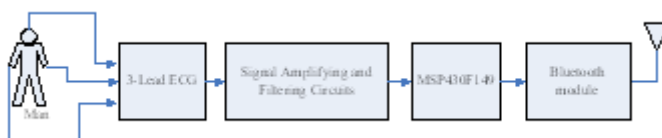


Fig. 1 Diagram of System Components

* Corresponding author. Tel.: +86-13991917552
E-mail address: wang_peng_1@126.com.

3. Hardware Design

The core part of the device is MCU chip. It selects the Texas Instruments MSP430 family of ultra low-power microcontrollers MSP430F14x which consist of several devices featuring different sets of peripherals targeted for various applications. The chip features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that attribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than 6 μ s. So it meets the requirements of this design.

3.1. MSP430F149 Circuit Design

The MSP430x149 is microcontroller configurations with two built-in 16-bit timers, a fast 12-bit A/D converter, one or two universal serial synchronous communication interfaces (USART), and 48 I/O pins. The typical applications include sensor systems that capture analog signals, convert them to digital values, and process and transmit the data to a host system. It has low supply voltage range, 1.8 V to 3.6 V. The minimum system circuit of MSP430F149 is shown as figure 2 [2].

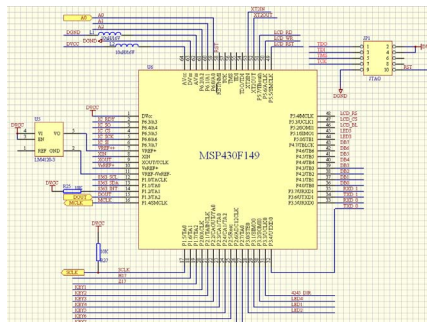


Fig. 2. MSP430F149 Minimum System Circuit

3.2. Bluetooth Interface design

The Bluetooth module selects GL-6B which is a Class 2 Bluetooth module using BlueCore4-AudioROM chipset from leading Bluetooth chipset supplier Cambridge Silicon Radio. GL-6B interfaces up to 8Mbit external Flash memory. When used with the CSR Bluetooth software stack, it provides a Bluetooth specification V2.0+EDR fully compliant system for data and voice communications. The operating frequency band of GL-6B is 2.4GHz - 2.48GHz unlicensed ISM band. Its operating voltage is 3.3V. The Bluetooth interface circuit is shown as figure 3.

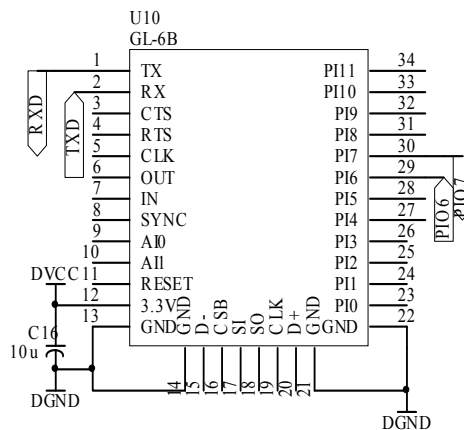


Fig. 3. Bluetooth interface circuit

3.3. ADC Interface design

The msp430F149 has 12-Bit A/D Converter with Internal reference, sample-and-hold and auto scan feature. The ADC12 module supports fast, 12-bit analog-to-digital conversions. The module implements a 12-bit SAR core, sample select control, reference generator and a 16 word conversion-and-control buffer. The conversion and control buffer allows up to 16 independent ADC samples to be converted and stored without any CPU intervention. The ADC interface circuit is shown as figure 4 [3].

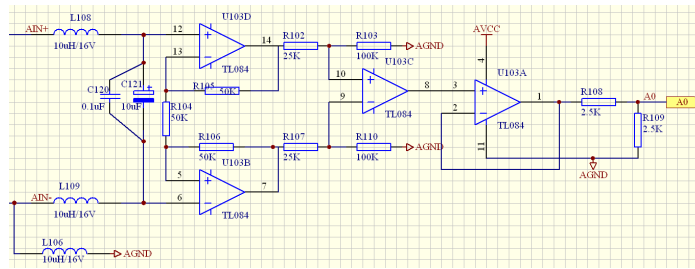


Fig. 4 ADC Interface Circuit

3.4. Power module design

The device is a portable instruments, so it powered by a battery. The battery provides 3.3V power; the MSP430F149 has low supply voltage range, 1.8 V to 3.6 V.

4. Software Design

The workbench of the design is IAR Embedded Workbench. IAR Embedded Workbench Kick start for MSP430 is an Integrated Development Environment (IDE) for building and debugging embedded applications for MSP430 microcontrollers. IAR Embedded Workbench with its optimizing C/C++ compiler provides extensive support for devices in MSP430X families and generates very compact and efficient code. Built-in plug-in to various hardware debug systems and RTOS are included in the standard edition.

The main program of the design is data acquisition program and data transmission program. The system software flow chart is shown as Figure 5.

Before establish the Bluetooth link and the sampling time hasn't reached the situation, it begin collect data, start Ad conversion; then select one signals of the three signals. After ADC conversion it open two buffers A and B in the storage data and determine which data is stored to the buffer by determining the buffer flag. After received 1500 bytes in the buffer it set the sending flag to 1. The ADC conversion flow chart is shown as Figure 6^[4].

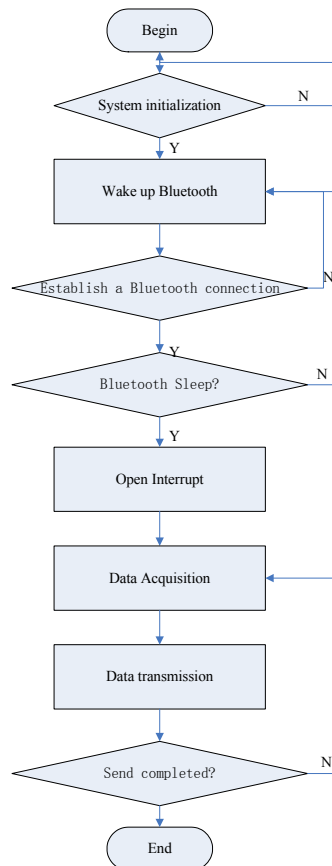


Fig. 5 Software Flow Chart

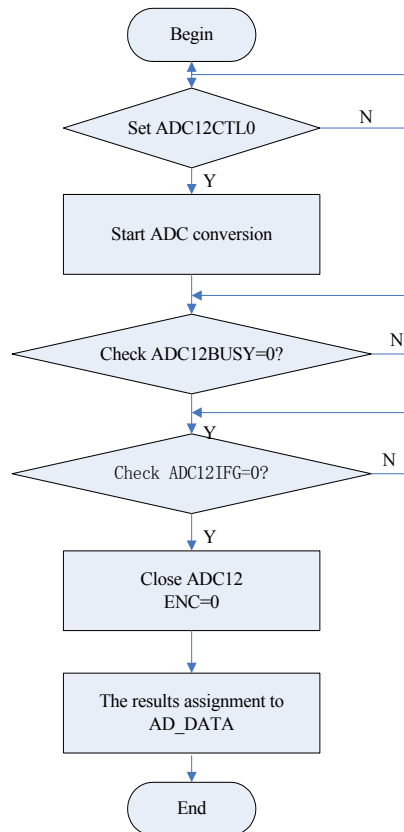


Fig. 6 ADC Conversion flow Chart

The wireless communication technology of this design is Bluetooth technology. MSP430F149 which used in the 16MHz frequency uses serial communication with the Bluetooth module and the asynchronous serial communication baud rate is 460800. The serial communication protocol is shown as table 1.

Table 1. serial communication protocol

Command Type	Command Frame	Command functions
Send Data Frame	0XFF 0XCC 0XCC 0XFF	Request to link with the Bluetooth
Receive Data Frame	0XFF 0X11 0X11 0XFF	success link with the Bluetooth
Receive Data Frame	0XFF 0X00 0X00 0XFF	Disconnect link with the Bluetooth

5. Debugging and Simulation

5.1. Theory Test

The theory test of the systems is carried out through the signal generators.

The debug step is:

- connect JTAG interface to the simulator and PCB board accurately;
- plug the Bluetooth adapter with a USB socket into the main chassis;
- insert the lead wire in the signal generator and open the signal generator;

When need to download the program, first open the program, compile and then press the switch, click on the download command, the program will be downloaded successfully. Secondly press the switch, the power light flashes normally, and open the Bluetooth connection interface, search for Bluetooth devices, then establish the Bluetooth links. After the success of a link, open the host computer interface, clicking on the link command. Eventually the correct waveform is shown on PC. The waveform of theory test is shown as figure 7 [5] [6].



Fig. 7 Waveform of Theory Test

5.2. Human testing

The next step is connects the device to the human body for true testing. There are two cases of the real test, one is static test another is dynamic test. The waveform of static test is shown as figure 8. The waveform of dynamic test is shown as figure 9.



Fig. 8 Waveform of Static Test

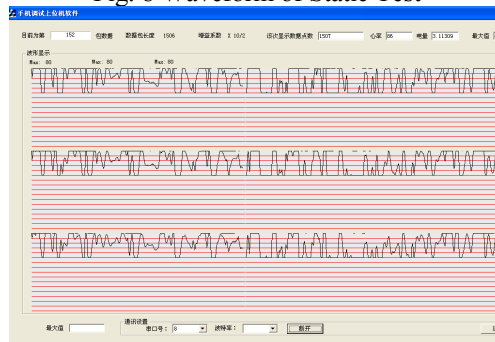


Fig. 9 Waveform of Dynamic Test

According to figure 7 and figure 8 shows, the measured ECG shape is regulation when people in the static (i.e., moving as little as possible), however the measured ECG shape is disarray when people in the static (i.e., move around and talk). According to the above test, the patient when using this product, we recommend that it best to sit-ins, walk less, and the measuring effect will be perfect [7].

6. Conclusions

In summary, the traditional monitor cable transmission is not convenient, expensive, so it can't meet the needs of most patients. This paper introduces the design process of a 3-Lead ECG acquisition device. The traditional monitor cable transmission is not convenient, expensive, so it can't meet the needs of most patients. This device uses wireless transmission, powered by the battery power, it can work long hours and has low cost, low power consumption, so it's the best option of family and community services applications. This device can create new areas of ECG acquisition system.

7. References

- [1] Don WenQuan, Wang RenHuang. The Low-power design of MSP430 MCU system. MICROCONTROLLERS & EMBEDDED SYSTEMS. 2003.1
- [2] ZHANG Shi Dong Jian-wei WANG Jun-hui ZHAO Shan-guo YU Jian-xi . Low-power design of wireless ECG monitor,. CHINESE MEDICAL EQUIPMENT JOURNAL.2006.26
- [3] CHEN Jing CHENG Nan XIANG Kui. Design and Simulation of Low Power Portable ECG Monitor. JOURNAL OF WUHAN UNIVERSITY OF TECHNOLOGY(INFORMATION & MANAGEMENT ENGINEERING) . 2009 31(3)
- [4] YUAN Zheng Dao ZHU Can Yan . Design of dynamic electrocardiograph acquisition system based on MSP430, APPLICATION OF ELECTRONIC TECHNIQUE, 2008 34(12)
- [5] TI Instruments Incorporation. MSP430x13x MSP430x14x MIXED SIGNAL MICROCONTROLLER
- [6] Rajgopal S. Challenges in Low-Power Microprocessor Design. 9th International Conference on VLSI Design, Jan.1996:329-330
- [7] Hattori T. Design Methodology of Low-Power Microprocessors. Design Automation Conference, Jan.2003:390-393