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Miniaturized Two Electrode ECG System for High Motion Ambulatory Environment with Bluetooth Connectivity

Kirthana T , Monisha K, E Mahalakshmi, G S Sahana, Rampur Srinath
Information Science and Engineering, The National Institute of Engineering, Mysore , Karnataka, India

ABSTRACT

Nowadays, due to advancements in technology the world is moving towards miniaturizing devices in various fields. This also includes medical field where the physician can effectively analyze various disease. The proposed system helps the doctors to perform preliminary diagnosis of the heart. There are several ways of diagnosing and checking the condition of heart such as ECG, MRI, CT Scan. ECG is preferred because of its precision, convenience and low cost. The proposed system has an ECG ASIC i.e. MAX30003 provides ECG waveforms and heart rate detection. The system also has an arduino pro mini 3.3V which collects data from ECG ASIC and sends to PC through HC-05 Bluetooth. Then, the ECG waves are displayed on the PC. The components used for the construction of the system are of low cost, high precision and low power consumption. The system enables wireless transmission of ECG signals to a PC through Bluetooth. The advantage of the system is compactibility and portability.

Keywords. ECG ASIC (MAX30003), Arduino Pro Mini 3.3V, HC-05 Bluetooth, Wireless transmission

I. INTRODUCTION

The modern lifestyle has lead people more prone to cardiovascular diseases. Cardiovascular disease is a common class of disease which involves heart and blood vessels. Angina, myocardial infarction known as heart attack and Bradycardia are some of the commonly known coronary artery diseases. This is caused by high blood pressure, excessive alcohol consumption diabetes, smoking, obesity, high blood cholesterol and lack of exercise poor diet. ECG is the most common method of diagnosing heart diseases. Electrocardiography is a process which records electrical activity of the heart using electrodes placed on the skin. An abnormal ECG can tell irregular heartbeat, an enlarged heart, areas of the heart with reduced blood supply, a silent heart attack. ECG method is used when a patient is suspected with cardiovascular system.

The contraction and relaxation of the cardiac muscles result in generation of electrical potential. Electrodes detect the tiny electrical changes on the skin.ECG interpretation requires a structured assessment of the waves and the intervals. There a 5 waveforms of ECG, P wave, Q wave, R wave, S wave, T wave. P wave is the initial deflection of the heartbeat and it is a small upward wave. It depicts atrial depolarization. The Q wave is any initial downward deflection after the P wave. The normal Q wave indicates septal depolarization. The R wave is the next upward deflection after the P wave . It is represented by early ventricular depolarization. The S wave is the first lower deflection that appears after the R wave. It represents the late ventricular depolarization. The T wave represents repolarization of the ventricles.

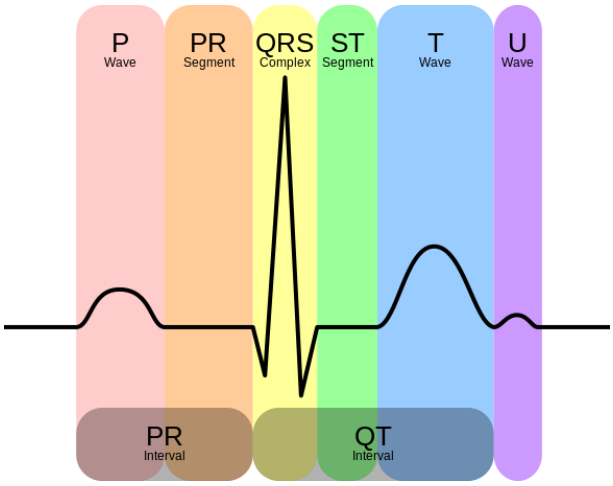

Figure 1. Waves and Intervals of ECG waveform

A normal resting heart rate for adults ranges from 60-100 beats per minute. If a resting heart rate is consistently above 100 beats per minute or if it is below 60 beats per minute then hear rate is considered to be abnormal and should be diagnosed.

Due to the exponential development of the information technology, there are some ECG monitor products which uses technologies such as Internet solutions, Bluetooth, cellular phones[6], and wireless local area networks(WLAN)[1]. Transmission of ECG signals by Bluetooth and wireless networks has an impact in the market and has been used extensively[2]. The proposed ECG system has advantage of interfacing the ECG signals on PC through Bluetooth connectivity.

II. HARDWARE DESCRIPTION

A. Arduino Pro Mini 3.3V

Arduino Pro Mini is a microcontroller board based on the ATmega328P. It consists of 14 digital input-output pins, 6 analog inputs, a reset button and holes for mounting pins. Arduino Pro Mini is used for semi-permanent installations. The pin layout of the board is compatible.

There are two versions of Pro Mini. One runs at 3.3V and 8MHz, the other at 5V and 16MHz. Here, Arduino Pro Mini 3.3V is used. It doesn't have any pre-mounted headers, users can connect a connector or wire in any orientation.

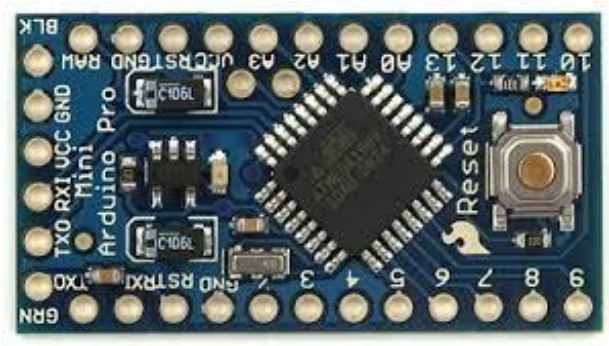

Figure 2. Arduino Pro Mini 3.3V

B. Power Supply

The power supply to Arduino Pro Mini can be given via an FTDI cable or breakout board or with a regulated 3.3V supply on the Vcc pin. Automatically the power source will be selected. The external power supply can be either from a battery or an AC to DC adapter. The unregulated power is connected to RAW pin on the board not on Vcc.

C. Ag/AgCl Electrodes or Conductive Fabric Electrodes

Ag/AgCl are traditional medical electrodes, used to sense the tiny electrical signals of the muscles, when dampened. An adhesive gel is used to stick electrodes on the skin [3]. They may cause irritation to the skin and retain on the skin for long time causing side effects. Conductive Fabric Electrodes are used for sensing muscle activity. It is a simple way to make reusable electrodes and are of low cost. They are sown into garments or used as a strap. Conductive fabric based electrodes are capable of collecting ECG with accuracy compared to that of the signal collected by the gel electrodes.

Since, no any adhesive is used in conductive fabric, no pain or irritation is caused to skin.

D. Bluetooth Chip

Bluetooth is used as a wireless transmission interface to transmit the ECG signals to PC. HC-05 Bluetooth

communicates with Arduino via Serial Communication

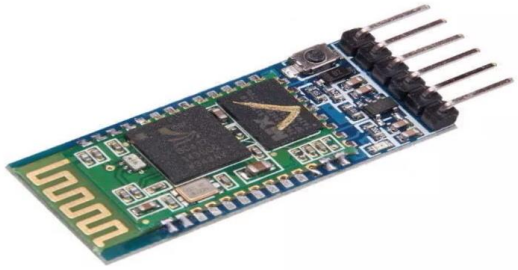

Figure 3. HC-05 Bluetooth

E. ECG ASIC

The MAX30003 is a single bio-potential channel which provides Electrocardiogram (ECG) waveforms and heart rate detection. It is a complete, biopotential, analog frontend solution for wearable applications. It consumes ultra-low power for long battery life. It provides high performance for clinical and fitness applications. Some features of MAX30003 are - It has a built-in Heart Rate Detection with Interrupt feature which eliminates the need for running HR Algorithm externally [5]. It has better dry starts due to improved CMRR and high input impedance. Due to high accuracy more physiological data can be extracted.

III. SOFTWARE DESCRIPTION

Processing is a flexible software sketchbook. It is built on Java language with simple syntax and a graphical user interface [7][8] .

IV. PRINCIPLE OF OPERATION

The two electrodes are placed on left and right arm of the subject. These are connected to MAX30003 an ECG ASIC. This ECG ASIC has an in-built ADC to convert the analog ECG signal to digital one and a Heart Rate Detection algorithm to calculate the heart rate. These digital data are then sent to Arduino board where the data are stored, formatted and made ready to get transmitted [4]. The HC-05 Bluetooth is connected to Arduino Pro Mini 3.3V. This bluetooth module is used to connect to PC. The PC receives transmitted data through the in-built Bluetooth settings.

The program is made to run and then the ECG signal is displayed on the screen. This heart rate is also displayed.

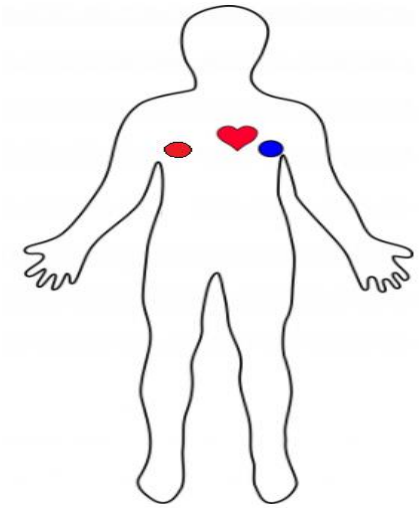

Figure 4. Two electrodes placed on the subject

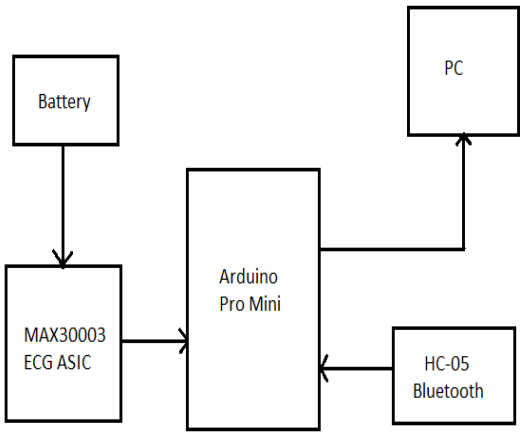

Figure 5. General Block Diagram

V. RESULTS

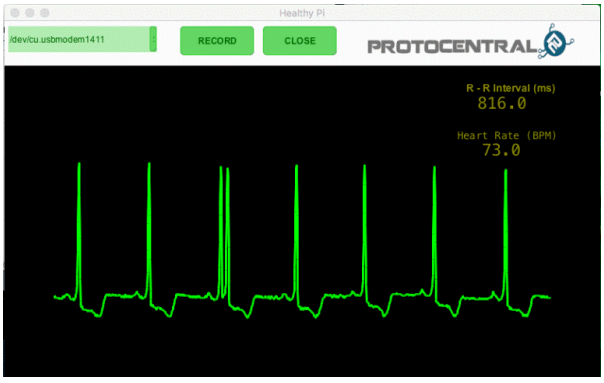

Figure 6. ECG signal acquired through conductive fabric.

Figure 7. ECG signal acquired through Ag/AgCl electrodes

The above results depict clearly that the ECG signal acquired by conductive fabric are more accurate than that of Ag/AgCl electrodes. The waveforms displayed are more clear in Fig6 and are easy to make diagnosis of the heart.

VI. CONCLUSION

In this paper, MAX30003 ECG ASIC is used to calculate the Heart Rate. An Arduino Pro Mini 3.3V, used is of low cost and small in size. The ECG signals acquired are processed accurately and made to display on the screen. This system detects the ECG signal when the subject is ambulatory.

The conductive fabric used instead of traditional electrodes increases comfortability for the subjects. Unnecessary, noise is removed and required ECG signals are displayed.

VII. FUTURE WORK

The current system displays the heart rate and R-R interval distance on the screen. This can be further modified to obtain few more necessary information to be displayed on the screen by making simple modifications in the program. The signals transmission distance is limited in this system. This can be improved by adopting new technologies which support long distance transmission.

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