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Design and Implementation of Low Cost ECG Monitoring System and Analysis using Smart Device

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Abstract: Cardio vascular Diseases these days are becoming the prime cause for the death worldwide due to the increase in the consumption of junk and unhealthy living habits. These deaths are mainly caused due to the late stage detection and lack of diagnosis. Early detection and diagnosis can lead to the prevention of such diseases and ultimately death. The equipment necessary for such detection are of large cost and hence for developing countries like India it isn't affordable for the people, hence this research work intends to design a low cost ECG generation circuit which can be used by the patient for instant ECG generation and probability of occurrence of any Cardio Vascular Disease. The ECG is transferred via Bluetooth to the PC, Where simulation software Such as MATLAB is used for the feature extraction of the ECG. This network can also be used to connect it to doctors for the immediate response and report.

Keywords : ECG, Cardio Vascular Disease, Feature Extraction Generator

I. INTRODUCTION

World Health Organization (WHO) says that more than 17 million people die annually from cardiovascular disease. "The Global Hearts", a new initiative from WHO, as it aims to beat back the global measures threat of cardiovascular disease, including heart attacks and strokes to people living in countries with limited resources or in low income groups.[1]. Majority of the death coming from the middle and lower order people. With early detection these deaths can be prevented but for middle and lower class people the service seems to be very costly hence leading to the negligence of the fact but with low cost ECG generator circuit and analyzing this pattern leads to hint about the diseases such as Tachycardia, Myocardia, Coronary Artery Diseases, Congestive heart failure and many more.

ECG was first invented in the year 1901 by Willem Einthoven using a string Galvanometer, He used the letters P,Q,R,S to denote the various activity of the heart. The present day medical science still use the same convention used by Willem in the year 1901.

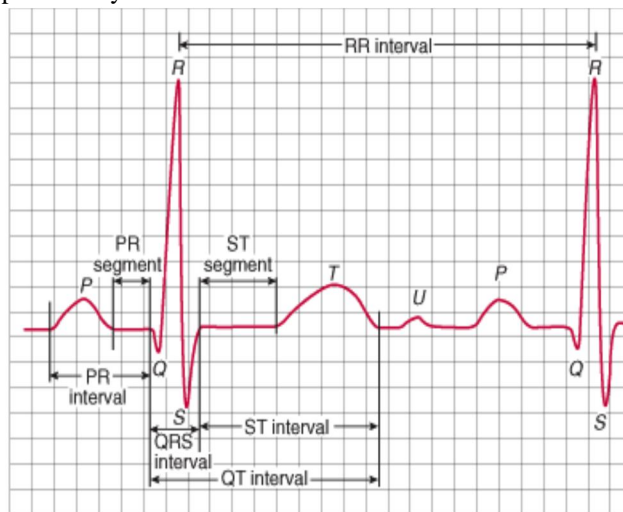


Fig.1. An example of ECG signal with specified waves, intervals and segmentation [2].

In this proposed paper a prototype ECG generator circuit is developed which is low cost ,battery powered making it portable and also includes wireless connectivity for transferring the signal to the PC and Smart Phone.

II. RELATED WORK

The present-day system for the diagnosis of the disease is diagnosis in the pathology center and then only taking the ECG report for testing, this conventional method is time consuming and there's a delay in the production of the result, hence today many new alternatives are used replacing the traditional system. Accordingly Home automation System is designed for the Cardiac Monitoring[2].This system is designed in such a way that it can only be used in the Home environment but the intended system can be used in any environment making it versatile and very user friendly. The Cardiac condition of the user can also be monitored Continuously [3]. The 3 major components include a disposable electrode, a controller, and personal gateway (e.g., cellular phone, PDA, and smart phone, etc.). Gimenez et al. developed a Lifestyle Change Supporting System (LCSS) for Integral community cardiac rehabilitation based on technological platforms [4].Hoff et al. made a dedicated ultrasound system to check cardiac function continuously during cardiac surgery and post-surgery time [5].These systems used a 10MHz transducers planted directly on the surface of the heart. All these systems had some design issues and cost factor played a very crucial role, hence our proposed system was developed which is portable and can be used in any environment with cost factor being minimum and very affordable to all the lower and middle class family in developing countries like INDIA.

III. SYSTEM ARCHITECTURE

The present day smart phones have high transmission power and features like Bluetooth and wifi (IEEE 802.15.1).Among the present Smart Phones Android dominates with 81% phones running on Android[4],making it an attractive platform for viewing the ECG signal. Arduino Uno is a low power and highly efficient microcontroller board based on the ATmega328. It has built in ADC and USART communication feature. In this system, for analog to digital conversion and serial transmission of the ECG signal Arduino Uno is used.

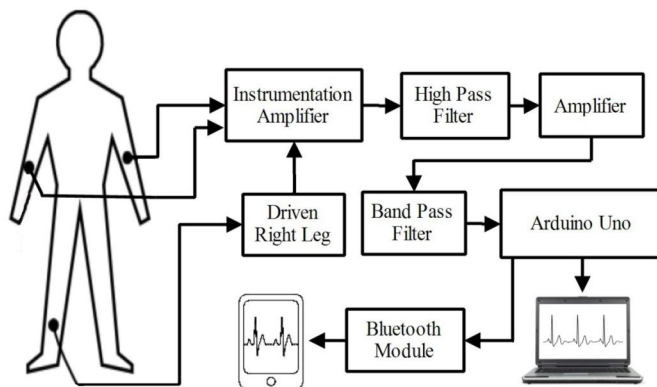


Fig. 2. System Architecture of the ECG monitoring system.

IV. METHODOLOGY

The proposed system basically consists of 4 units ,a sensor units consisting of ECG electrode, a signal conditioning unit, Filter and a Bluetooth module for transferring of the data. ECG Acquisition: For acquisition skin surface electrode Ag/ Ag-cl electrode is used. These signals are transferred to the amplifier using the patient cable Signal Conditioning: The quality of the signal obtained is affected by skin electrode interface, electrode motion artifact, electrical interference, semiconductor noise generated in the amplifier, and input signal level variation. In the proposes system we have used a AD620 amplifier because of its easy availability, low cost and high precision. It has a CMRR ranging from 100 db to 1 khz.Also the total required gain is in the range of 700 which is achieved by using two stage amplification as shown in the figure using the AD620 and CA3130 which is used as the non inverting amplifier[5].The gain of AD620 is calculated using the equation.

$$Gain = 1 + (49.4k/Rg)$$

All the filters used are passive first order filters and the cutoff frequency is calculated using the equation[6].

$$Fc = 1/(2 * \pi * R * C)$$

The ECG signal obtained is super imposed by various noise such as power line interface and common mode signals. The line interface are usually 50-60Hz and is eliminated using the DC supply from battery. The common mode signals are eliminated by the use of right leg drive. It inverts and amplifies the average common mode signal back into the patient's right leg, which cancels line frequency noise and also improves the common mode rejection ratio [7]. The internal ADC of Arduino Uno works between 0V to +5V[8].

For serial communication pin 1 and pin 0 of Arduino Uno needs to connect with Bluetooth modules Rx and Tx and figure shows the connection. A Bluetooth module HC-06 does signal transmission between Arduino UNO and Android phone. Arduino Uno can also communicate with laptop via USB cable.

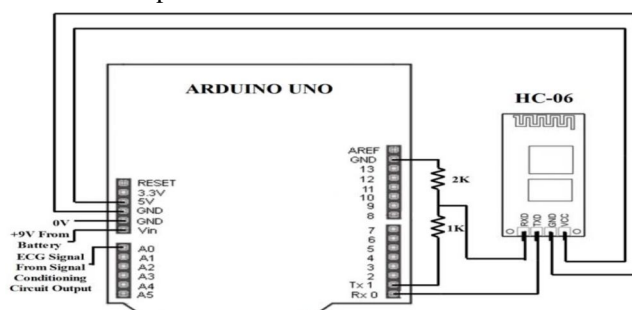


Fig. 3. Arduino connection to Bluetooth

V. FEATURE EXTRACTION

In this paper we also propose an feature extraction method that can be applied to the ECG signal that has been obtained from the generation Circuit so that we can extract the important features. Zhao et

al. [9] proposed a feature extraction method using wavelet transform and support vector machines. Castro et al. in [10] which is a proposed novel approach for ECG feature extraction based on wavelet transform and recognition of abnormal heartbeats.

Different types of feature are extracted from the generated ECG signal which include R-R interval-Q-wave interval ,P-wave interval. Among them the R-R interval is used to for the detection of the different abnormalities.

For the R-R detection we propose a method that uses the simulation Software such as Matlab.Signals are analyzed using the simulation software for the detection of the abnormalities,Also the heart rate calculation is done for the detection.The Steps approaches in the following manner.

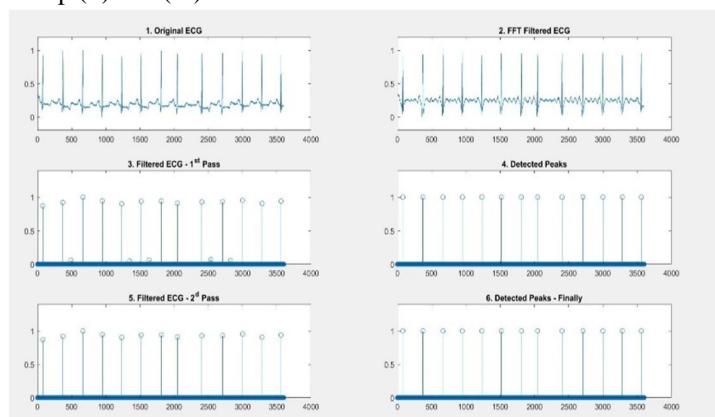
A. Remove the low frequency Component

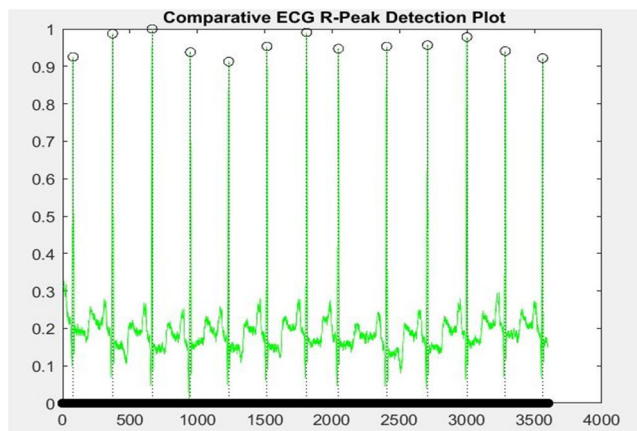
- 1) Change to frequency domain using FF
- 2) Remove low frequency Componen
- 3) Back to time domain using FFT

B. Find local maxima using Windowed Filter

C. Remove Small values and store Significant one

D. Adjust Filter Size and Repeat step (ii) and (iii)





Command Window

```
>> ecgdemo
Average Heart Rate =
    80.6202

R-R Interval=
    0.7442
```

VI. CONCLUSION

This paper proposes a low-cost ECG monitoring system which is portable and handy for the use in any environment, also it proposes steps for the analysis of the acquired ECG signal in a simulation software such as MATLAB where the abnormality detection can be done calculating the Heart Rate and the R-R interval. The System also proposes a connectivity using the Bluetooth module through Arduino which can be used to transmit the data to any PC or Mobile phone through which it can be sent to the doctor in any location.

Thus, through this system timely monitoring of the Heart condition can be done and the abnormality can be detected early leading to the reduction of the death of patient due to the cardiac diseases also the system is battery operated making it portable for use in any remote places and under any circumstances.

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