

Real Time Heart Rate Monitoring Using ECG lead electrodes

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ABSTRACT: Nowadays monitoring of heart rate regularly for all age group is becoming very important to overcome sudden death syndrome, caused due to unexpected heart failure. Electrocardiograph (ECG) is the primary method for accurate detection of heart rate significantly in the medical field.

This paper aims in design and development of low cost, lightweight, portable ECG measuring system for continuous and easy monitoring of an individual. The developed model acquires ECG signals and given to ARM7-LPC2148 for analog to digital conversion of ECG signal. The digital data is processed using MATLAB for detection of algorithm based QRS complexes of ECG signal from which heart rate is computed continuously.

KEYWORDS: ECG, QRS Detection, Heart Rate Monitoring, Analog to Digital Converter, Portable, MATLAB.

I. INTRODUCTION

The ECG (Electrocardiogram) is perhaps the most preferable technique used in recording and interpretation of electrical activity of heart muscles over time by placing electrodes on limb or chest surface. This wave was developed by William Einthoven in 1901, and he was awarded the Nobel Prize in Medicine for his work. A typical ECG signal representation is shown in Figure 1. P wave denotes the process of depolarisation of atria, QRS complex reflects the depolarisation of ventricles, R-spikes indicate heartbeat and finally re-polarization of the ventricular myocardium is given by T wave. It is the accurate way to measure and diagnose the heart for any abnormal rhythms.

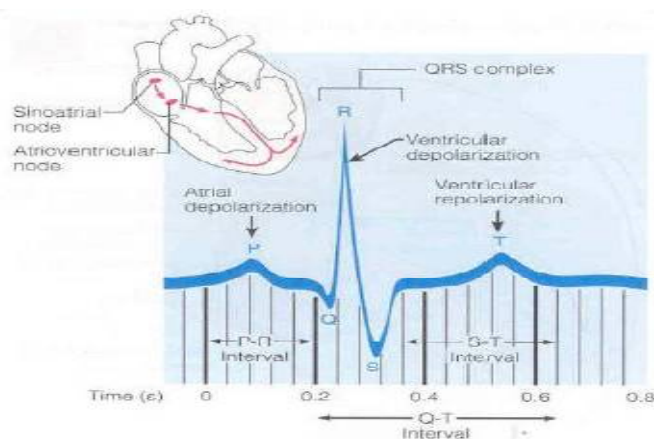


Figure 1: A Typical ECG

In particular, rhythm due to damaged conductive tissue that carries electrical signals or by electrolyte imbalances can be diagnosed very well. Currently there are hundreds of portable ECG monitoring systems available in market. But,

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generally have some drawbacks such as- bulky to carry, complex circuit structure, non-real time monitoring, expensive, etc. To overcome the disadvantages, we design a portable system with simple structure, small size and easy to carry. In the proposed work, ECG data is taken from the designed system and given to PC which is programmed to display heart rate of an individual and various abnormalities such as tachycardia and bradycardia. Acquisition and real time monitoring of ECG signal is made possible all times with this design. The real time data is transmitted from the system to PC through USB interfacing for further analysis such as – QRS detection, RR intervals, Heart Rate. The QRS detection is based on a famous Pan Tompkins algorithm.

The heart rate is calculated by measuring the time interval between two consecutive R peaks (RR-intervals) and the reciprocal of averaged value of RR-intervals gives heart rate, which is a unit of beats per minute (bpm). This paper is organized as follows. Section II describes few previous works of researches. In Section III, the overall architecture and working of the proposed system is described. In Section IV, the details of hardware implementation of individual blocks are given and the results obtained for processed data are presented. Concluding remarks are given in Section V.

II. BACKGROUND

Electrocardiography was done conventionally using bulky ECG machines in hospitals. The system interpreted the ECG waveform on a graph paper which was later studied for determination of the abnormality. The commonly known drawback with the system was not portable and not real time. The graph reading was a manual activity was prone to error. Also the patient cannot be monitored continuously during routine activities such as – eating, walking, etc. This made the researchers to find out something that could bring ECG measurement out of the hospitals and into the hands of the layman bringing into effect the introduction of small sized portable ECG monitors based on microcontrollers that could process the signal in no time and give parallel results.

Christopher M. Tenedero has suggested the general ECG circuit design used traditionally. It is composed of 2 electrodes making a single channel lead I ECG transmit the signal to the conditioning and processing circuitry started by an instrumentation amplifier which magnifies the minute signals and make them bigger with respect to the noise they are coming with. This is followed by an isolation amplifier which helps in rejecting common mode noise and protects the patient from cardiac shocks etc. This is followed by a band pass filter made up of resistors, capacitor and/or op-amps which helps in passing the ECG signal only and rejecting the noise coming with it. The right leg drive amplifier too is used for suppressing common mode interference. Then processing is done a second time using digital filters after digitizing the signal through a data acquisition board and finally concluded by a display unit that shows the ECG waveform.

Hailong Jin has suggested the design of Holter ECG System based on MSP430 and USB Technology that is compact and low power run by a battery having large amount of memory. In this project he has assembled together a preamplifier module, 50 Hz notch filter, secondary amplifier filter module and MSP430F149 microcontroller whose program is burnt on 16 bit Flash chip used separately. The communication between these components is made possible by a USB controller. The most significant aspect of the project is the use of filter chips that could be programmed to act as any filter and he has made a 50Hz notch filter in it.

III. SYSTEM ARCHITECTURE

The Figure 2 shows the overall architecture of the proposed work. This module starts with the electrode sensors, from which data is given to the amplifier. Then the pre-processed data is given to microcontroller to perform analog to digital conversion. Then finally converted data is plotted on PC/ Laptop in real-time and further processing.

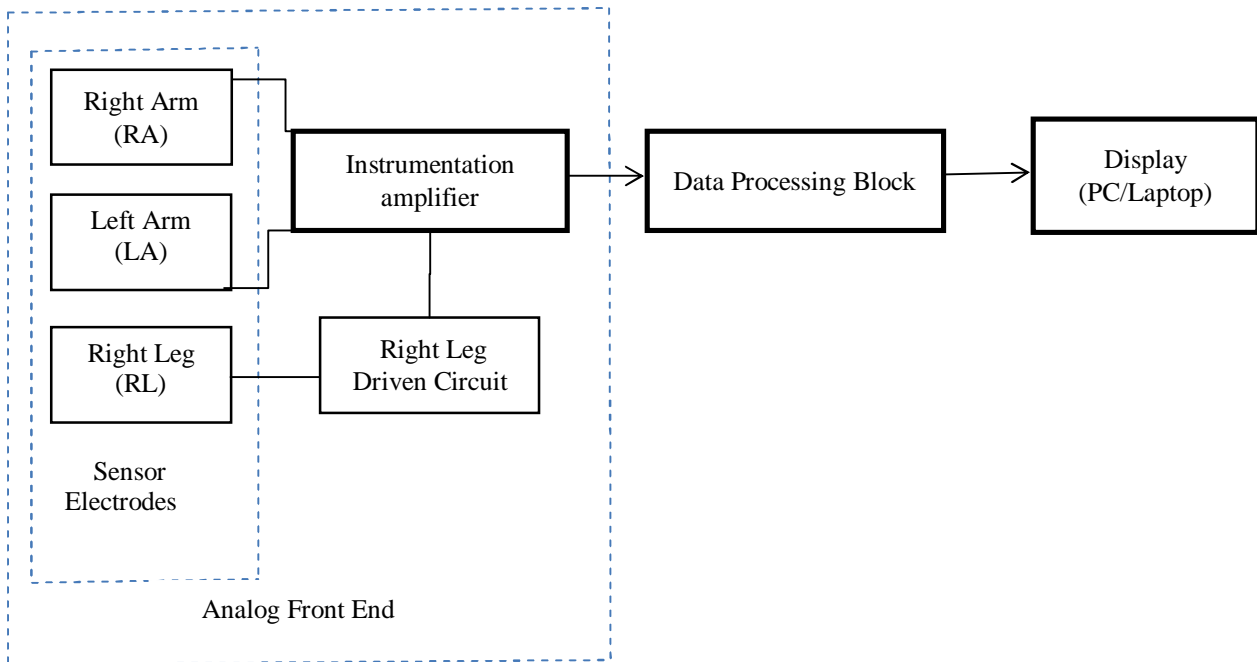


Figure 2: Block Diagram of Proposed Work

A. Analog Front End

The Subject is made to sit on a chair and theraw signal obtained from disposable button type ECG electrodes, figure 3(a). The AG/AgCl element are solid conductive & uses adhesive Hydro-gel for adhesion. The 3-lead ECG electrodes are applied to the individual’s right hand, left hand and to the right leg as shown in Figure 3(b)

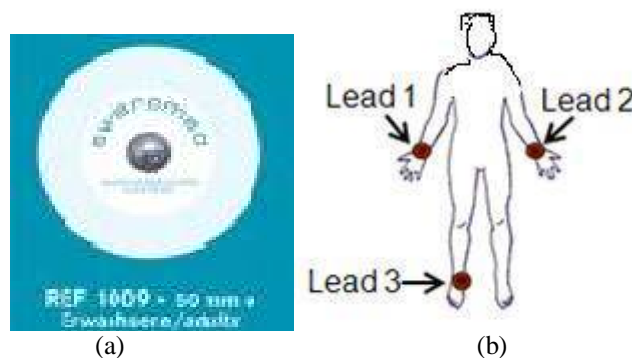


Figure 3: (a) Ag/AgCl electrode, (b) 3-lead electrode placement based on Einthoven’s triangle

The analog front end circuit includes amplification and filtering of acquired ECG signal The ECG signal obtained is given to AD620 instrumentation amplifier, to amplify the ECG signal. Here the amplified ECG signal is not given to series of filters to eliminate power line and EMG interferences. The raw data is given to inbuilt ADC of ARM controller to convert the analog data to digital form and is given to PC for further digital processing.

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(An ISO 3297: 2007 Certified Organization)

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B. Data Processing Block

The final data from the AFE is given to PC for further processing. At first QRS complexes of obtained ECG are detected based on Pan Tompkins algorithm. Figure 4 shows the methodological flow of Pan Tompkins algorithm.

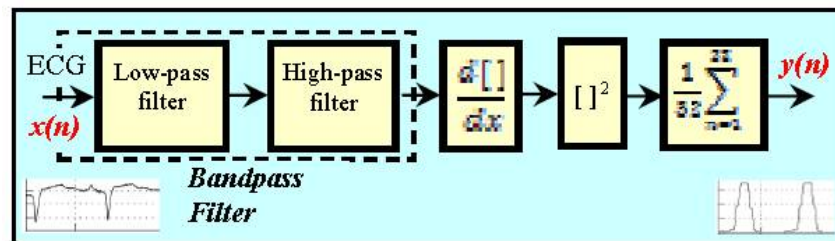


Figure 4: Pan Tompkins algorithm

Pan Tompkins algorithm of QRS complexes detection is implemented using MATLAB. This algorithm begins with the ECG undergoing various digital filtering such as – low pass filter, high pass filter

Step 1: Low pass filter: This stage provides a greater attenuation and suppresses power line interference, if they are present.

Step 2: High pass filter: This can be simply said as- “All pass filter” – “low pass filter”.

Step 3: Derivation: This stage finds the high slopes of QRS by suppressing the low frequency components of P and T waves and also provides high frequency gain for QRS complexes.

Step 4: Squaring: All data point is made positive by squaring every point one by one and emphasizing the higher frequencies.

Step 5: Integration: The squared waveform passes through a moving window integrator and finally adaptive thresholding is used for detection of R peaks (Figure 5)

Figure 5 shows the ECG waveform with QRS complexes marked.

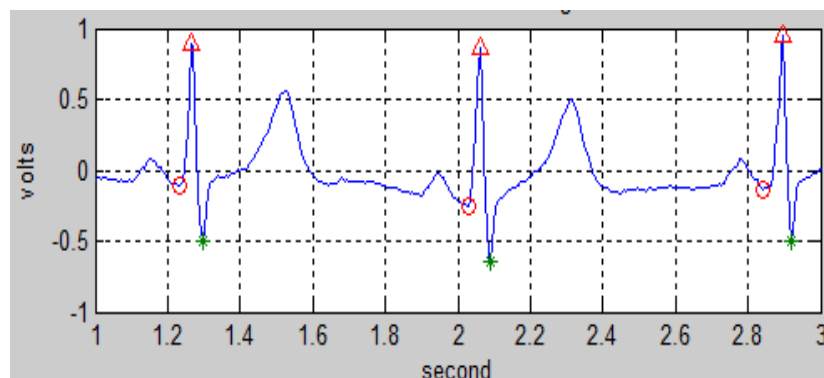


Figure 5: QRS peaks detected

R peaks are the basic requirements for calculation of heart rate. The time interval between two consecutive R peaks is taken to be an important parameter of heart rate. The normal sinus rhythm of heart is said to be in the range between 60 to 100 Beats per Minute (BPM). As mentioned earlier in this work along with regular monitoring of heart rate, two kinds of heart rate abnormalities – Sinus Tachycardia (when the average heart rate exceeds above 100 BPM) and Sinus Bradycardia (when the average heart rate is below 60BPM) are also determined.

IV EXPERIMENTAL SETUP AND RESULTS

Figures show the experimental setup with the results obtained after each stage from data acquisition to heart rate determination. Figures 6 (a), (b) shows the experimental setup of data acquisition circuit and 6(c) shows the ECG data on CRO acquired from a subject

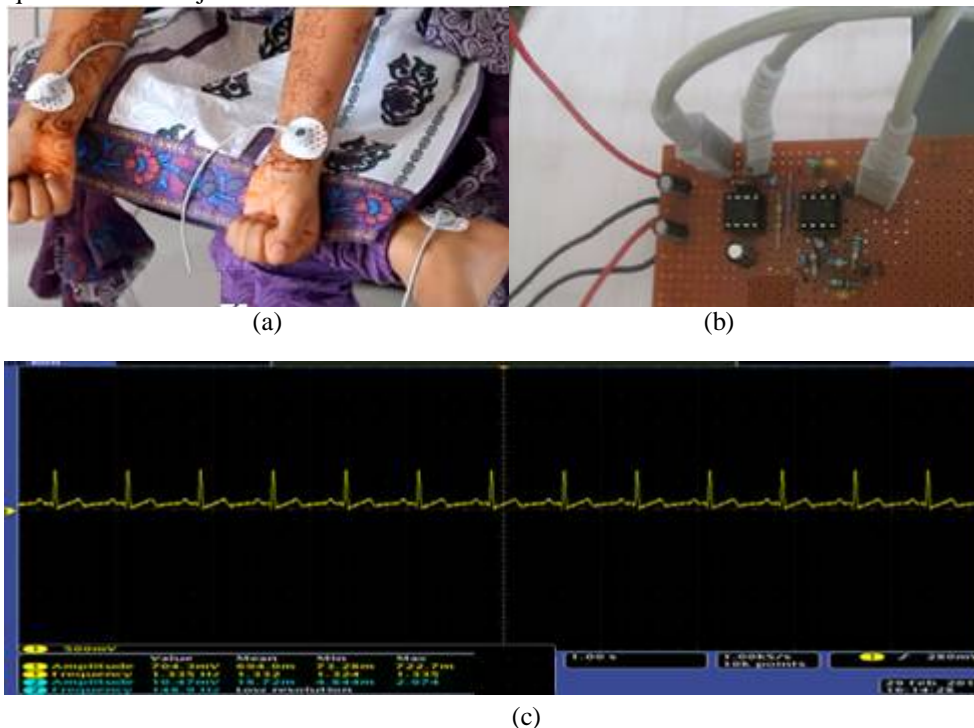
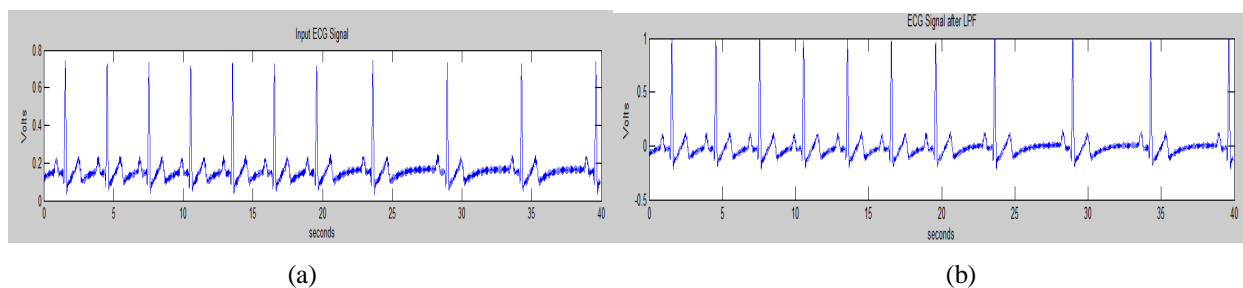


Figure 6: (a) Subject connected with 3-lead electrodes, (b) Analog circuit for ECG data acquisition, (c) Digital CRO output of analog circuit

Figure 7 and 8 gives graphical representation of the ECG signal being processed using Pan Tompkins algorithm for the detection of QRS Complex and RR intervals respectively.

In Figure 7, (a) shows the acquired ECG data from the hardware designed, (b)& (c) shows the digitally low pass and high pass filtered data, (d) is derivative , (e) is squared and (f) is moving average window result. At last the QRS peaks are marked as shown in (g).



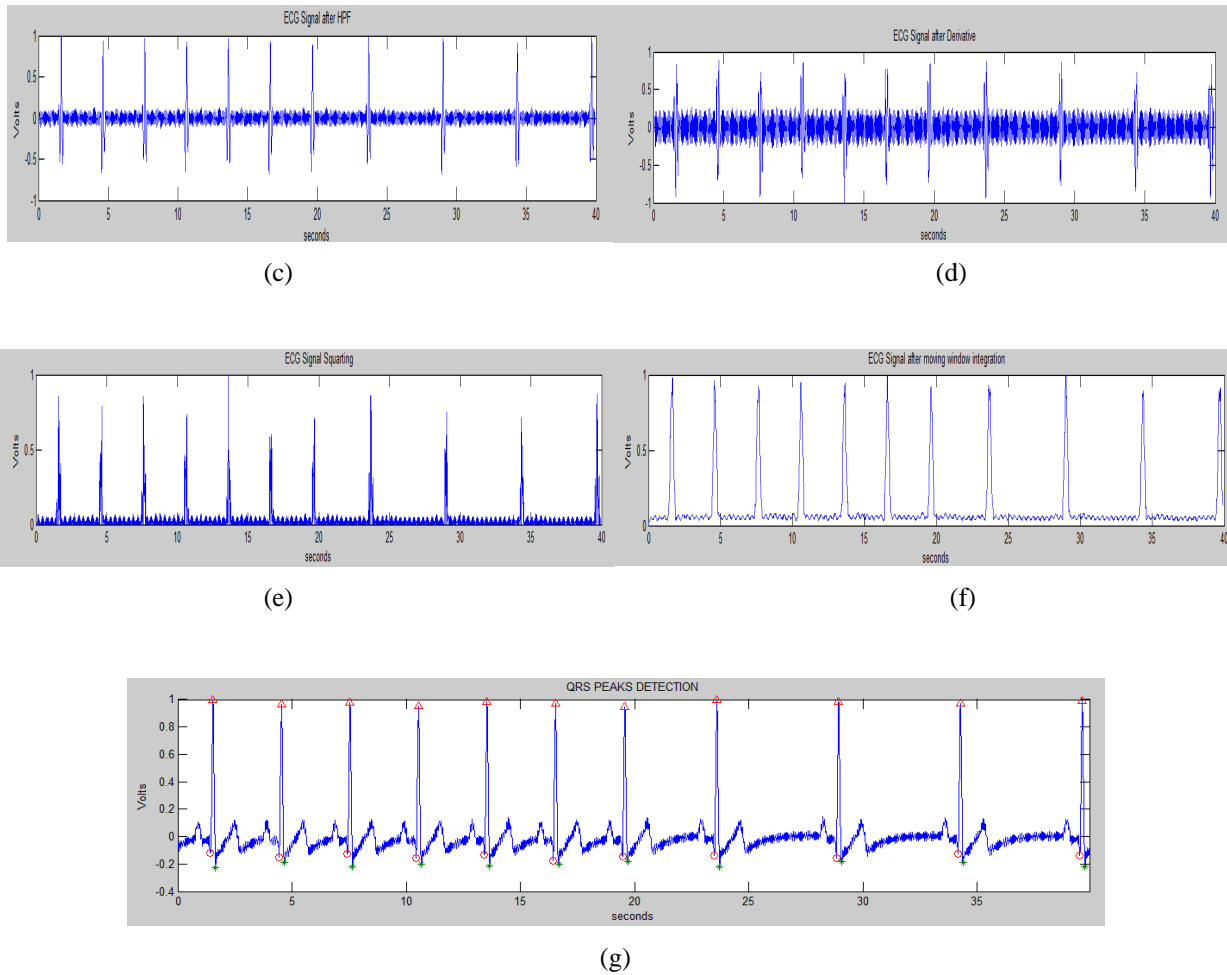


Figure 7: Waveforms of the implemented algorithm using MATLAB (a) ECG input signal, (b) Low pass filter, (c) High pass filter, (d) Derivative, (e) Squaring and scaling, (f) Moving Window Integration (g) QRS Detection

Figure 8 shows RR intervals, which gives the heart rate.

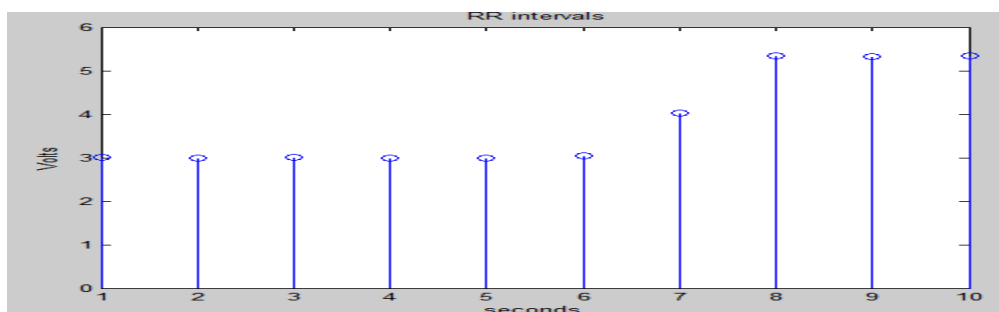


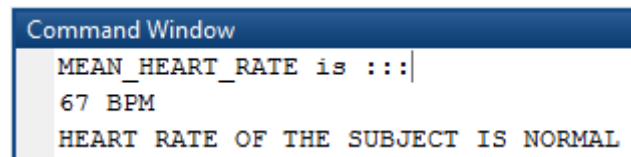
Figure 8: RR interval representation

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Figure 9 shows the MATLAB command window display, where mean heart rate value is displayed saying, the heart rate of the subject is normal.



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Command Window
MEAN_HEART_RATE is :::|
67 BPM
HEART RATE OF THE SUBJECT IS NORMAL
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Figure 9: Display of Normal heart rate in BPM

V CONCLUSION AND FUTURE SCOPE

In this article heart rate is monitored in real time using 3-lead ECG electrodes. A prototype was built and testing by taking ECG data of many individuals. MATLAB code was written using Pan Tompkins algorithm to detect the QRS complexes of obtained ECG signal and RR intervals were found by considering peak of two consecutive R peaks of ECG waveform. From the time interval of RR, a condition of heart rate is determined. The proposed work can be extended to find Heart Rate variability and time/frequency domain parameters, from which various health abnormalities can be predicted.

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BIOGRAPHY

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