Wearable Wireless Electrocardiogram Monitoring System

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***Abstract*—Electrocardiogram (ECG or EKG) is the process of recording the electrical activity of the heart over a period of time using electrodes placed over the skin. By ECG we can measure the heart rate of a person and we will also be able to know the present situation of the heart of a patient. In this paper, we will show a design of showing the ECG Signal in real time through a portable device like mobile/tab/laptop and measure the heart rate and showing it in the portable devices also. Moreover, the full design is wearable. So there is no need for any kind of wired connection. The patient can wear this device very easily, he can move anywhere he wants and the doctor will be able to monitor him from any place of the world. By doing this, we will be able to identify the heart problems of a patient through a portable device. We will also be able to take immediate actions for the betterment of the patient. So, this wearable wireless ECG monitoring system will allow both the patient and the doctor very easy and flexible and after all a secured life.**

***Index Terms*—Electrocardiogram, Portable Device, BPM, Heart Rate, Bluetooth, WiFi, Server, Low pass filter, Band pass filter, Heart block**

I. Introduction

Nowadays, heart diseases are very common. For this reason, real time monitoring of a patient is very essential. Sometimes it becomes so much tough to monitor the patient by taking place beside him. For this reason, there is need of a portable device, which will allow the doctor to go outside as well as monitoring the patient to take proper steps. Electrocardiogram(ECG) is a big way to realise the present condition of heart patient properly. In this paper, we proposed a method of real time plot of electrocardiogram of a patient in a remote device. By doing this, a doctor can observe a patient by using a portable device from distance. So, this method will help both the patient and the doctor for the betterment of life of both of them. In this paper we proposed total three methods of transferring ECG data. We will also show a practical implementation of a method.

II. Related Work

Nowadays technology has enriched each and every sector in many ways.In this recent world everything is automated like E-voting [1], [2], supply chain management [3],robotics [4], vehicle registration [5],national identity card management [6],sentiment analysis [7],applications for own security [8], [9] and so more.On the other hand, an analysis of the dynamic activity is proved that peripheral organ [10] systems have provided robust indicators. It also proved the discriminative capability of mental stress with respect to sustained attention.The development [11], [12] of health care in human life since the development of IT tools or healthcare-related software.IT technology is currently being widely used in the efforts of scientists to deal with the most dangerous novel corona virus. The system that detects COVID-19 in the first infected state is being implemented only through the IT system. An electrocardiography (ECG) monitoring system is being used extensively to improve signal detection, portability and power consumption reduction. The paper of Sumit Majumder, Leon Chen, Ognian Marinov [13] showed that ECG electrodes absorb a small amount of energy and can be used to diagnose various human diseases, as well as the amount of energy that can be used.In another case [14]–[16] of combined ECG dinging, a linear synchronized array structure of ECG detection, lossless data compression can be used for resulting in a 3.1 wave conversion-based output.Identification of heart abnormalities, best known as the ECG method. Currently, [17], [18] 12-lead ECGs are converted to recording devices that are made from single ECGs available.In the current era, smart ECG monitoring on Android platform is being measured by data using Android's Bluetooth module and mobile phone application.In addition to gaining knowledge through SDIA to present ECG features. In this paper, BT and MBT methods [19] had used for selecting very important samples and WDDB database has worked on amazing deliveries to deliver the output.Other's a paper [20], [21] is proving that it is possible to present ECG observations as a high input for wearables only as low noise AFE IC.

III. ELECTROCARDIOGRAM

Electrocardiography (ECG) is the process of recording the electrical activity of the heart over a period of time using electrodes placed over the skin. It is very commonly performed to detect any cardiac problems. Between the ECG components,the P wave is a record of the electrical activity through the upper heart chambers (atria). The QRS complex

is a record of the movement of electrical impulses through the lower heart chambers (ventricles). The ST segment shows when the ventricle is contracting but no electricity is flowing through it.The T wave shows when the lower heart chambers are resetting electrically and preparing for their next muscle contraction.

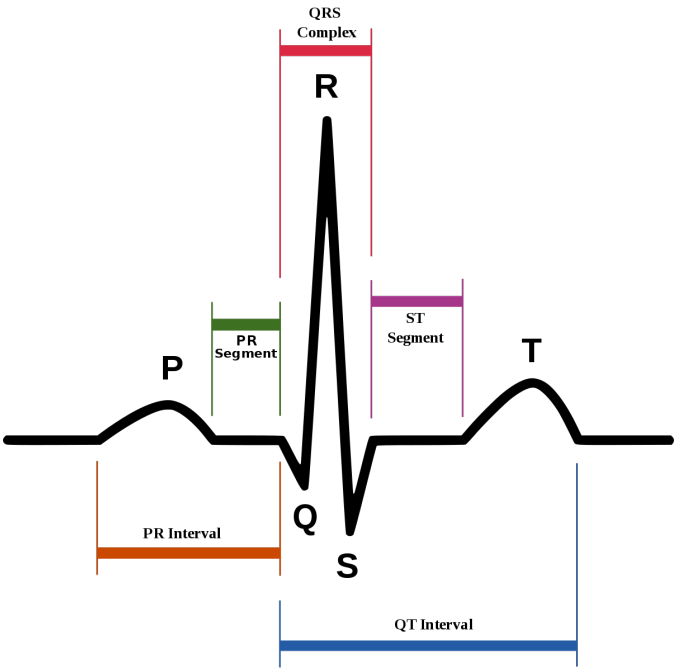

Fig. 1: Flowchart for determining heart state

IV. HEART RATE

Heart rate is the speed of the heartbeat. It is measured by the unit named BPM(beats per minute). BPM refers to the number of heartbeats detected during one minute. Basic method of determining BPM from ECG is, by measuring the fundamental frequency from ECG by Fourier Transform and then multiply it by 60.

$$BPM = FundamentalFrequency * 60$$

V. COMPONENTS

Components' descriptions are given in this section of this paper.

A. AD8232: Electrocardiogram Sensor

In this paper, we used AD8232 as the ECG sensor. The pin diagram is shown in figure 2. We used RA, LA and RL pins to input the ECG data. Three electrodes are connected in Right Arm(RA), Left Arm(LA) and Right Leg(RL). These three electrodes data were sent to the sensor by using wire.Then the output pin was connected to the micro-controller. For safety purpose, there are LO+ and LO- pins, which indicates whether the electrodes were properly connected or not. So, these two pins were also connected to the micro-controller.

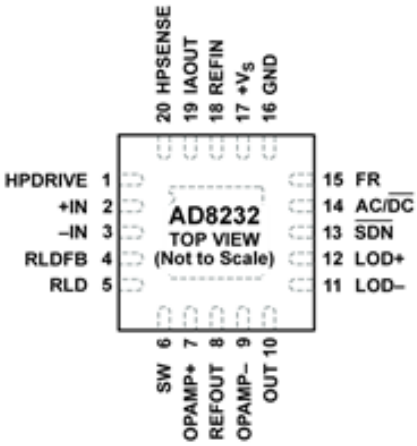

Fig. 2: AD8232 Pin Diagram

B. Arduino Uno

We have used Arduino Uno as our micro-controller board. Arduino Uno uses AtMega328p micro-controller, which has 20 MHz processor. The raw ECG data from the AD8232 sensor was sent to Arduino Uno. The output pin of AD8232 was connected to the Arduino Uno via analog pin A0. A0 pin receives the analog ECG data. Then the ECG data was filtered using bandpass digital filter in the Arduino Uno. After processing the data and measuring the BPM, the processed ECG data and the BPM were transferred through Bluetooth Device. In arduino uno, Tx pin is for data transfer and Rx pin is for data receive. By using these two pins, ECG data and BPM were transferred to Bluetooth Module.

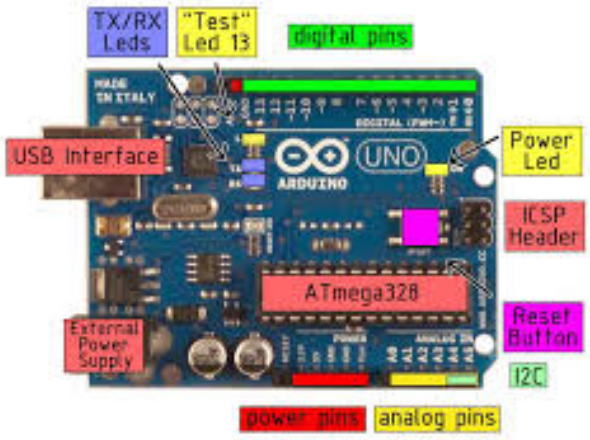

Fig. 3: Arduino Uno Pin Diagram

C. Wearable Belt

Easy movable and comfortable to wear belt to hold the ECG system over stomach.

D. HC-05 Bluetooth Module

As bluetooth Module, HC-05 was used. This module receives data from Arduino Uno and then transfer the data to Mobile and other portable devices via bluetooth. Bluetooth Module HC-05 receives the data from Arduino Uno. Arduino Uno's Tx pin is coneected to HC-05's Rx pin. Thus this module receives data from arduino uno and transfers the data via bluetooth.

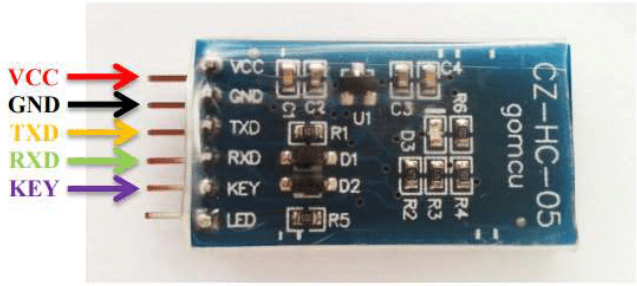

Fig. 4: HC-05 Pin Diagram

E. NodeMCU

NodeMCU is another micro-controller board which has builtin wifi module. Moreover it has ESP8266 microcontroller, which is 80 MHz micro-controller, which is much faster than Arduino Uno. We used this module as like Arduino Uno, but processing the raw ECG signal is faster here, because of faster processor. Moreover, there is no need of bluetooth module as Wifi module is built-in this NodeMCU. So, to transfer the data to server, and processing the data faster, NodeMCU is highly recommended as this Module is used for this purpose in this paper.

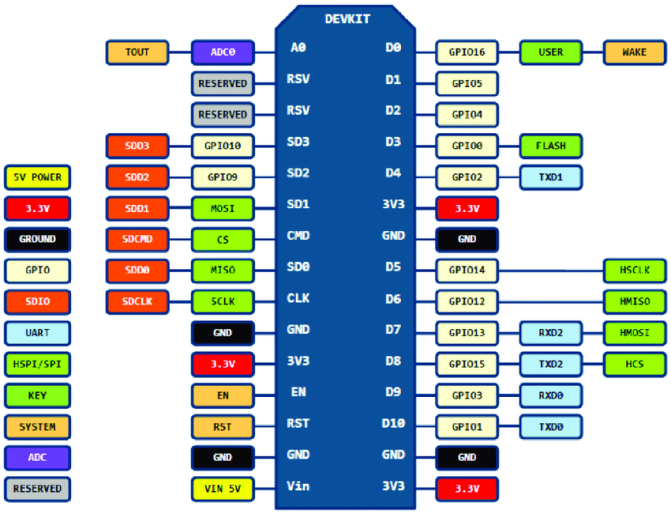

Fig. 5: NodeMCU Pin Diagram

VI. PROPOSED DESIGN

We proposed three methods of our project.

i. Using Arduino
ii. Using NodeMCU (processing data in its own processor)
iii. Using NodeMCU (processing data in SMART PHONE)

A. Using Arduino Uno

ECG Sensor (AD3282) is used to take the ECG data. For this purpose, these three input pins-RA, LA, RL are used. Output pin of the sensor is connected to analog i/o pin(A0) of Arduino. Tx and Rx pins are connected to Rx and Tx pins of HC05(Bluetooth Module) respectively. ECG Sensor takes the raw data from the body and gives these analog date to Arduino through analog pin A0. Then these data is filtered using a Low Pass filter in Arduino. Next FFT is performed on these Filtered data for finding the Fundamental Frequency component of the ECG data. Then BPM is calculated. BPM = (Fundamental frequency 60) bits per minute. Both Filtered ECG data and BPM are transferred to Smart Phone using Bluetooth Module. We will see the output data using RoboRemo App.

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Advantages:

i. WiFi is not required.

Disadvantages:

i. Too slow
ii. Size is large because Arduino and HC05 are separated devices.

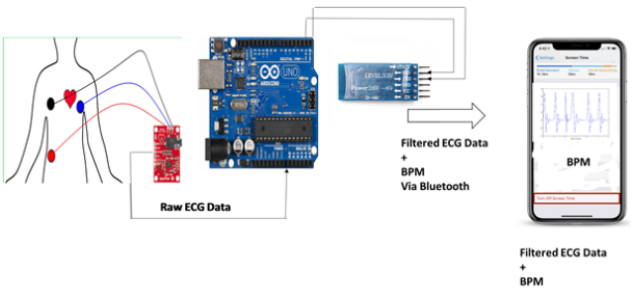

Fig. 6: Method Number 1 of Wireless ECG Monitoring System

B. Using NodeMCU (processing data in its own processor)

I/P PINS of ECG sensor RL,LA,RA is used to take the raw data from the human body. O/P pin is connected to the analog i/p pin A0 of NodeMCU. ECG Sensor takes the Raw data from the body and gives these analog date to NodeMCU through analog pin A0. Then these raw data are filtered using a Low Pass Filter just like 1st methodology. Next FFT is performed on these Filtered data for finding the Fundamental Frequency component of the ECG data. Then BPM is calculated. As NodeMCU is the combination of Arduino and WIFI module ,both filtered data and BPM are transferred to Firebase. In this case, WIFI connection is mandatory. We will see the output data using RoboRemo App.

Advantages:

i. More compact cause NodeMCU provides both WIFI module and Arduino.

Disadvantages:

i. Too slow.
ii. Data missing is occurred because processor of NodeMCU.
iii. Net connection is mandatory.

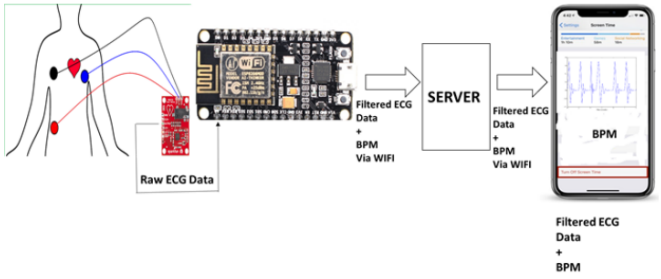

Fig. 7: Method Number 2 of Wireless ECG Monitoring System

C. Using NodeMCU (processing data in SMART PHONE)

I/P PINS of ECG sensor RL,LA,RA is used to take the raw data from the human body. O/P pin is connected to the analog i/p pin A0 of NodeMCU. ECG Sensor takes the raw data from the body and gives these analog date to NodeMCU through analog pin A0. These raw data are transferred to Firebase through WIFI. Then these Data are transferred to the smart phone. Hence WIFI is mandatory. These Raw data is filtered using low pass filter. Next FFT is performed for finding BPM. All these calculations are performed using the processor of smart phone Then ECG signal and BPM is seen using professionally paid app.

Advantages:

i. More compact cause NodeMCU provides both WIFI module AND Arduino
ii. Comparatively fast because of high performance processor of smart phone
iii. Data missing is not occurred

Disadvantages:

i. Net connection is mandatory

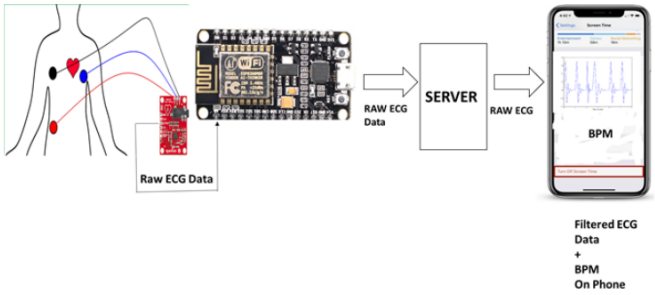

Fig. 8: Method Number 3 of Wireless ECG Monitoring System

VII. BANDPASS FILTERING

A bandpass filter is an electronic device or circuit that allows signals between two specific frequencies to pass, but that discriminates against signals at other frequencies. Bandwidth of ECG signal is 0.5Hz to 10Hz. That's why, cut off frequencies of the bandpass filter used in Arduino are 0.5Hz to 10Hz. MATLAB is used to get the transfer function of the required filter. Based on the SAMPLING TIME=30ms and CUT OFF FREQUENCIES are 0.5Hz and 10Hz.

Transfer function, $T(z) = 0.979/(z0.02305)$
In sampling domain, $y(n+1) = 0.02305y(n) + 0.979x(n)$

VIII. IMPLEMENTED SYSTEM

In this paper, we are showing the practically implemented system of one of our proposed methods. In real life, we implemented the bluetooth method of our proposed method. The overall system diagram is shown in figure 9 and figure 10.

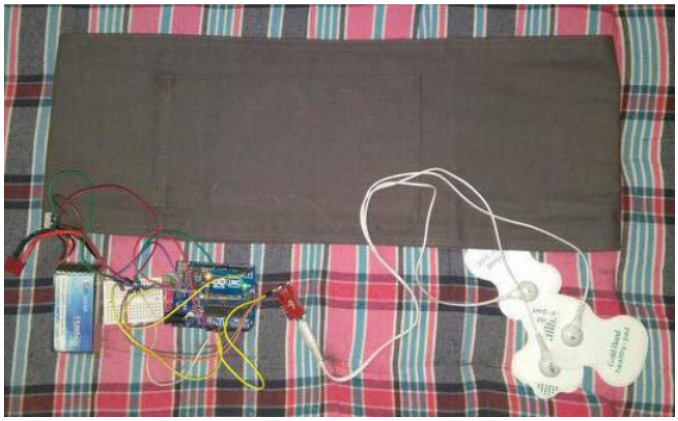

Fig. 9: Full Setup

Fig. 10: A person wearing the full setup

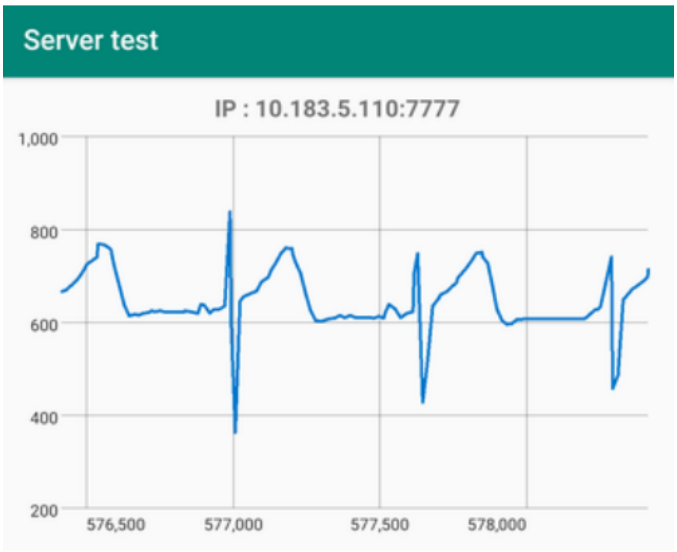

Fig. 12: ECG of a person in a mobile via WiFi

IX. RESULT

Output of the practically implemented system is shown in figure 11. Here we can see that, the BPM of the person, whose ECG is measuring is 73.82. We have seen the output through a Android Mobile Nokia 6.1 plus. Again, we can see the ECG of that person in the graph plot section.

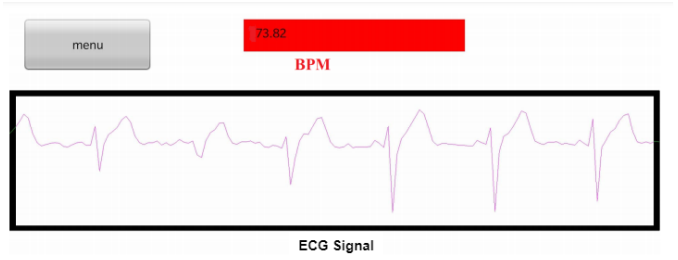

Fig. 11: ECG and BPM of a person in a mobile via Bluetooth

X. HUMANITARIAN EFFECT

A majority of the people in the world lose their life due to heart disease. The main reason for this is the huge amount of money required for heart treatment. This proposed method is small in size and easy to use. Also this costs way less than used method now a days. If this method can be implemented properly, it can make heart treatment economical. Many people in the world avoid heart checkup due to high cost and lengthy treatment. But this process can make heart checkup easy and comfortable. Traditional ECG measurement takes a lot of leads and wires. But as our method makes it wireless, it is easy to use. Also anyone can wear it and take a good look at their heart condition instantly.

XI. FUTURE PROSPECT

In future we will try to implement the design as clinical grade. Moreover by using neural networking, we will try to identify any kind heart disease, like heart block through this simple system. That will be too much beneficial for the human mankind.

XII. CONCLUSION

In this paper, an advanced method of obtaining wearable wireless ECG signal is proposed. This process is quite cheap considering the traditional methods that are used now-a-days. A person can stay home and learn significant features about his heart. Also it can be used to detect symptoms of various heart conditions. Emergency measures can be taken before it turns into a more severe form of disease. These above significance of this method can be used in large measures. Now-a-days heart disease treatment is a really costly procedure. Using this method, a large number of people can be saved from severe heart disease. Also as it is wearable, it can be used any time anywhere. It is easy and comfortable to use rather than traditional ECG generating systems. Proper implementation of this system can save a lot of money as well as lives.

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