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Wireless ECG Signal Monitoring System using Compression Technique through GSM Module

Amit Kumar Patel[1], Priyanka[2], Atanu Choudhury[3]

[1,2]Electronics and Communication Department, National Institute of Technology, Agartala Tripura, INDIA
[3]Asst. Professor, NIT Agartala, Tripura, INDIA

Abstract: This paper is all about a wireless ECG monitoring system which can not only sense the ECG signal but also analyze the signal and in abnormal situation transmits the ECG signal for instant action. It will also alert and provide detail of required action information according to the results of analysis. The aim of the paper is mainly to save the life of the patient having problem with their heart functioning. System will have electrodes to get the signal from body and the ECG analyzer which is composed of microcontroller will measure the heart beat and take the decision regarding panic situation. In case of panic situation signal will be transmitted using cellular network to the doctor through GSM module. The result of analysis will be used to display the name of the required medicine for emergency care at that moment of time which will save life. The complete system will be basically for a high cardiac diseased person and if they are moving or they are living alone this system will be greatly helpful to them.

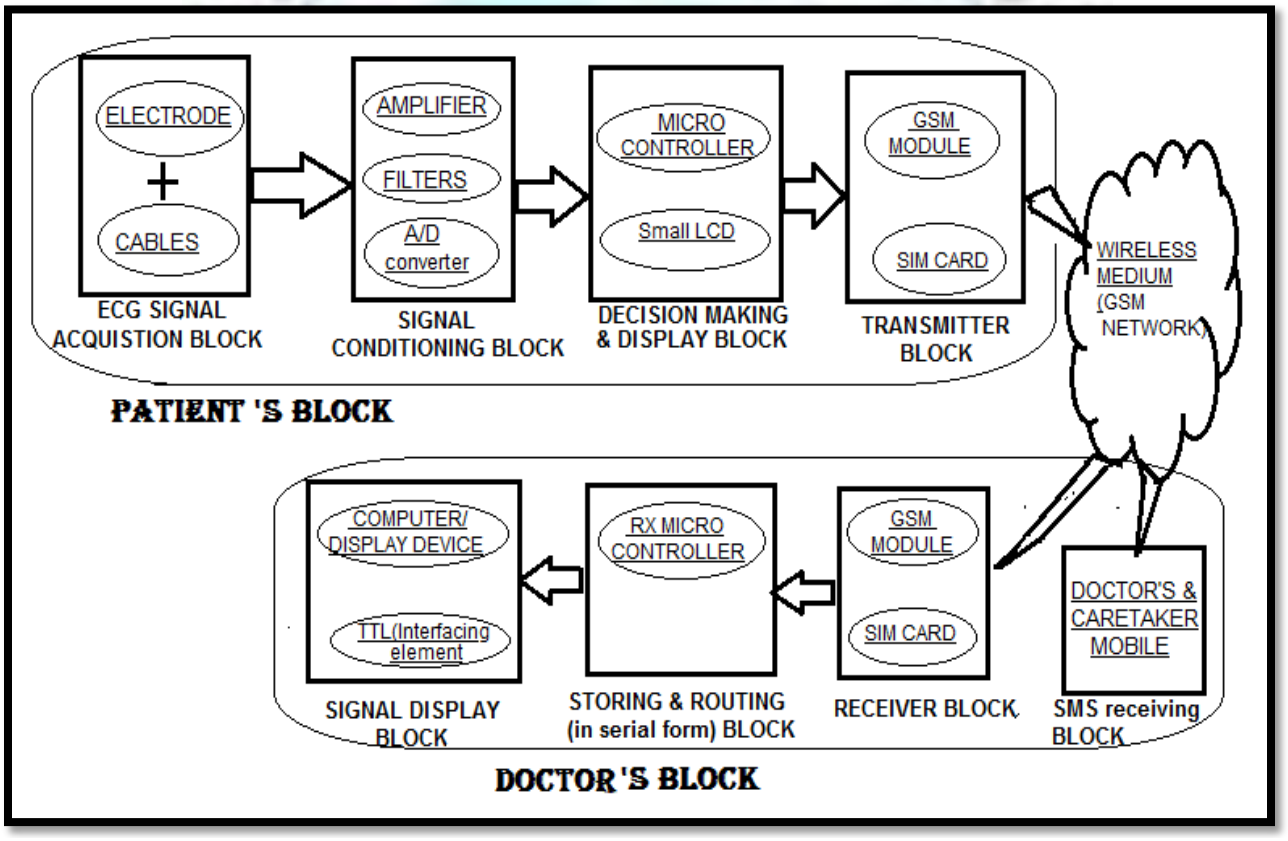


Fig 1: Block Diagram of Copmlete System

INTRODUCTION

In our proposed model the ECG signal is received from human body via electrode and this signal feed to the amplifier to amplify the signal, afterward the amplified analog signal is sent to the ADC of micro-controller. Here ADC converts analog signal to digital signal and give a numeric value continuously after few delay. If the numeric value crosses a limit set by programmer then the micro-controller send command to GSM via serial port to send the alert message for panic situation to caretaker and doctor. At receiver side the signal is verified and appropriate solution is send back via message. Before we go through the details of the system which is based on ECG we are giving here definition of electrocardiograph as a start up. It is a diagnostic instrument or tool which produce a plot of the electric behavior of the heart that is nothing but the current produced by contraction of heart. And this graphical recording is known as electrocardiogram.
To live a life with a disease is difficult but the most unmanageable is to be in a hospital as it makes the person kind of disabled. So here we need the wireless system which can be used anywhere anytime by patient to have freedom of movement. One of the most instant life taking disease is cardiac disease this takes life in seconds. So for this the heart activity that is nothing but ECG signal must be monitored continuously. For this purpose we are presenting here low cost, portable and bondable equipment which can be used as a kind real time monitoring of a patient and will be able to have instant reaction whenever a panic situation is created. This is helpful in many ways along with giving normal life it will make the hospital free for other serious condition patients and of course saves patients money and their caretaker's valuable time. For ECG monitoring other designs are also available but there features are in such a way that either they are mostly popular in some part of the world like US or less efficient than presented design. We have designed to make it available to everyone with better features. Here short comparison with some of related designs are given —

GSM-BASED ECG TELE-ALERT SYSTEM[1]:

It alerts in panic situation by sending the message to doctor but this system does not adapt the method for transmission of the ECG signal, this is what we have introduced in our design which is very important as according to doctor they can act upon instantly to the problem of patient accurately by observing the ECG signal .Because of the intelligent service of the smart mobile phones there are many design proposals which are based on it but there is a common problem to all of these designs as it uses a modern technology phone which is not very popular and usable to very common man and specially among old people but they need this kind of system. So for this specified reason we have used low cost GSM module for our project. Also it is safe and reliable to use this because mobile phone is used for multi functions and may be busy at the required time in some other place or may be off. Some designs based on mobile phones-----

LOCAL REAL TIME MONITORING SYSTEM USING MOBILE PHONE[2]:

This system is very good it will alert and transmit the signal on doctor's mobile but along with above problem it requires a slightly modified mobile phone, which has an inbuilt ECG analyzer and that's really a big problem because to order a phone with special feature will cost much and hard to get for a normal person. It uses Bluetooth for transmission of signal from patient to mobile which is somewhat unreliable for emergency case. A Mobile Phone Based Intelligent Telemonitoring Platform[3]:This system transmit and receive signal but to see the signal doctor has to search about the patient in the database so this is not very much instantly action taking system and as phone based so the above explained problem is also there. ECG signal transmission over the GSM Network[4]:In this system, ECG signals are transmitted in real time from the patients' locations in remote sites to specialists, normally in cities. There are two problems in this system one is it will not analyze for panic situation and other the system is very complex as it do the operation of transmission as a call.

Mobile Personal ECG Monitoring System and Transmission Using MMS[5]: It is very far from the feature of being an real time system because sending an MMS is really very much pricey and irregular type of transmission but in our system although we are sending signal just with a delay of 20 seconds but signal is send continuously so it's almost real time. This system uses Bluetooth which is a free band transmission which is not perfect. There are many others but that are different to this in some respect. After comparison with different designs we can conclude that all together our system has the three main advantages over other which makes it a practically acceptable design low cost, user friendly and reliable.

2. WIRELESS ECG TRANSMITTER DESIGN:

A. Electrode section:

ECG signals are picked up by electrodes made up of transducer **AgCl.** It converts the activity of heart (bio ECG signal) into electrical voltage. The voltages received from electrodes are in range of 0.1mv to 5 mV. There are five electrodes

connected to the human body (left arm, right arm, left leg, right leg, chest electrode).the signals of five electrodes are fed to the input of instrumentation amplifier of an overall gain of 1000.

B. Amplification section:

The signals obtained from ECG electrodes are very weak and need to be amplified from **mV** to **Volt** range. Here for the amplification purpose we have used AD624 instrumentation amplifier. It has very high common mode rejection ratio (CMRR) which is necessary for amplifying raw ECG signals. It is a high precision, low noise instrumentation amplifier and designed especially for ECG signals. The pin configurations of AD624 are shown in fig.1. A gain of 1000 can be setup by connecting 13, 3 and 11 pins.

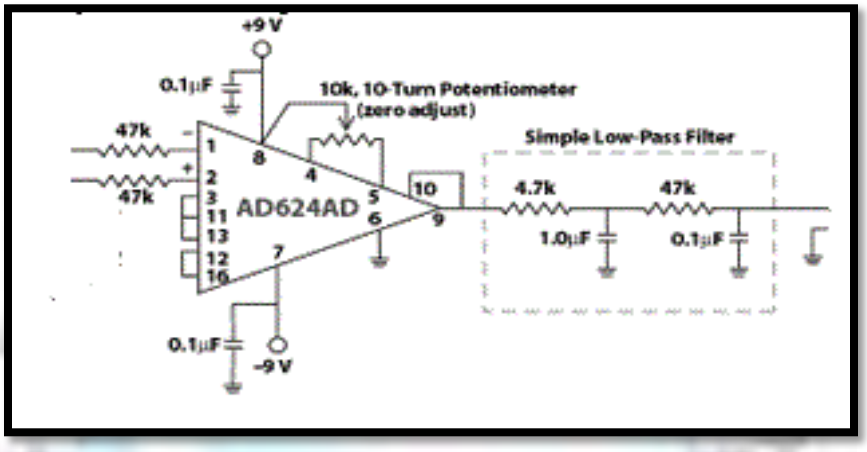


Fig 2: instrumental amplifier

Instrumentation amplifier AD620 can also be used as ECG amplifier in case of unavailability of AD624.

C. Filtering section:

The frequency range of ECG signal is 0.5Hz to 100Hz. So for filtering the amplified ECG signal is fed to high pass filter of cut-off frequency 0.5Hz followed by amplifier of desired gain and a low pass filter of cut-off frequency 100Hz. The high pass and low pass filter together works as a band pass filter and limits the frequency between 0.5Hz to 100Hz.

D. ADC section:

For transmission of ECG signal through GSM band we need to convert the analog signal into digital form.

PORT A of microcontroller **ATMEGA16** is used to give analog inputs to AD converter. AD converter will convert analog ECG signal into digital form and store it for transmission. PORT A of microcontroller has 8 channels of 10bit **ADC** is used for digitization. The analog ECG signal range is from 0 V to Vref.

$$\text{Unit Value} = V_{ref}/1024$$

According to the analog value it gives digital value between 0 and 1024.
The maximum frequency of ECG signal is 100 Hz .So according to Nyquist criteria the sampling frequency is 200 Hz.

E. Microcontroller section:

We have used ATMEGA16 microcontroller. It is a high performance, low power Atmel 8-bit AVR RISC-based microcontroller. It contains 16 KB of programmable flash memory, 1 KB SRAM, 512 B EEPROM, and an 8-bit A/D converter. It supports throughput of 16 MIPS at 16 MHz and operates between 4.5 and 5.5 volt. It is a powerful and flexible microcontroller. Since it is low cost so used in many embedded application.

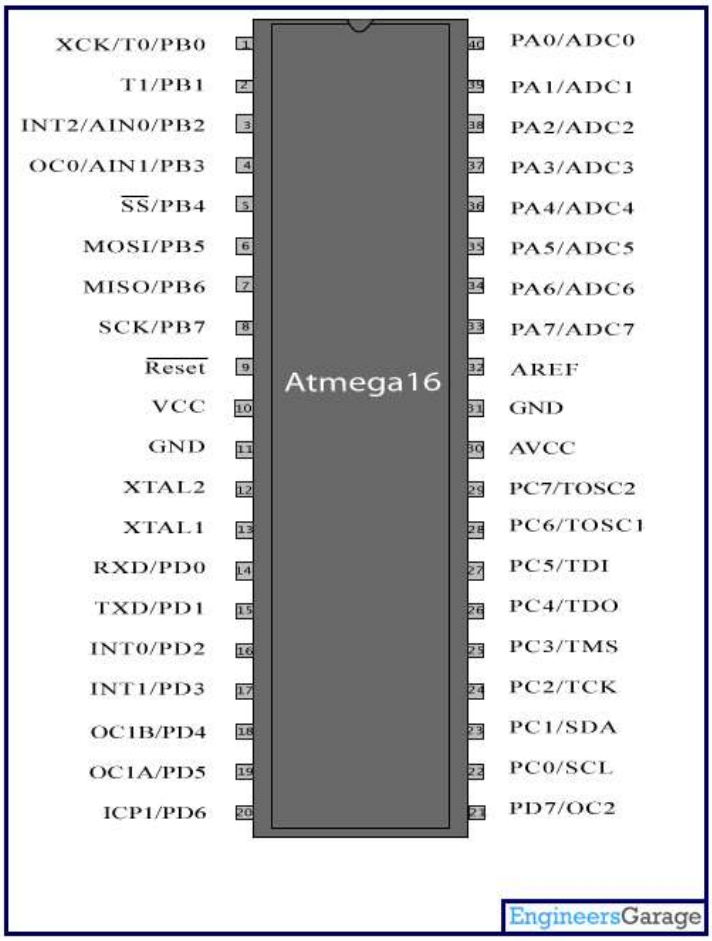


Fig: 3 Pin Diagram of Microcontroller

The ECG signal contains PQRS waves. The most significant part of ECG wave is R-R interval. It is used to find BPM (beats per minutes) of heart. It is the most sharp, steep and narrow part of ECG signal. So any panic situation or irregularity in heart will instantaneously reflects on R-wave.

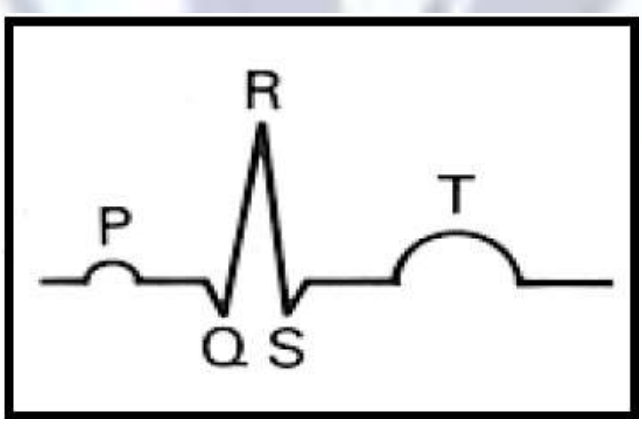


Fig: 4 Normal Ecg Sample

After analog to digital conversion of ECG signal by ADC PORT A of microcontroller, the digital samples of ECG are stored in memory. The code developed by us shorts the maximum R-points digital values and counts number of digital samples between two adjacent R-points. The time interval between two consecutive samples (sampling interval) is 5ms. If number of samples between two R-points is N. Then microcontroller uses the given formula to find BPM:

Beats per minute (BPM) = 60/ (N*5ms)

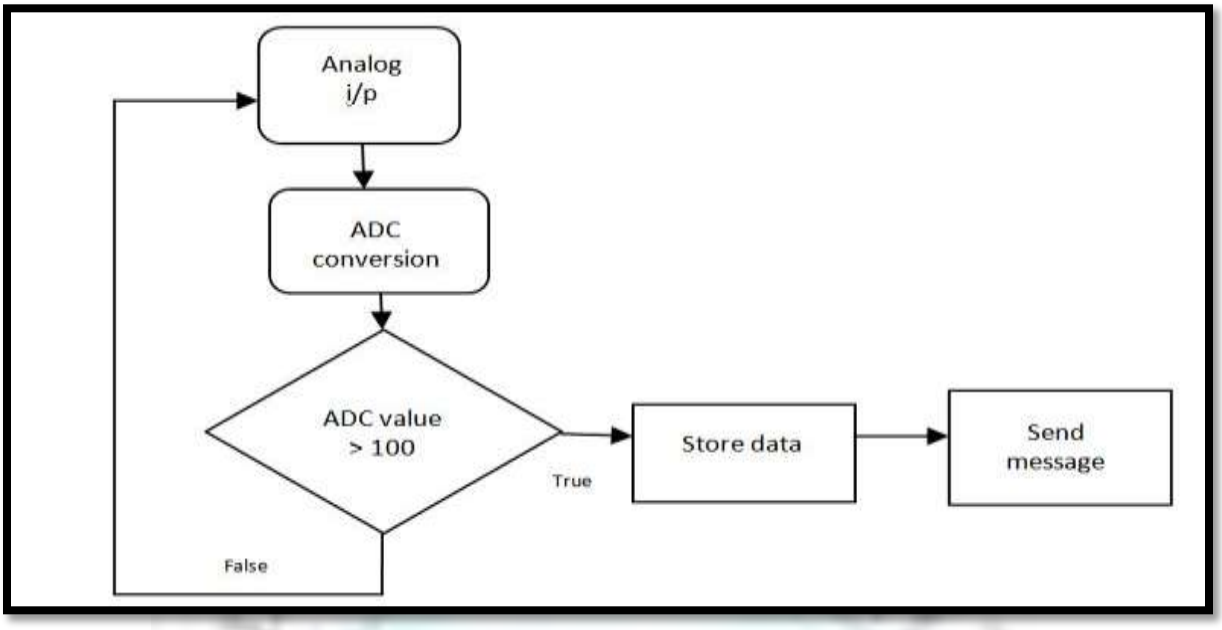
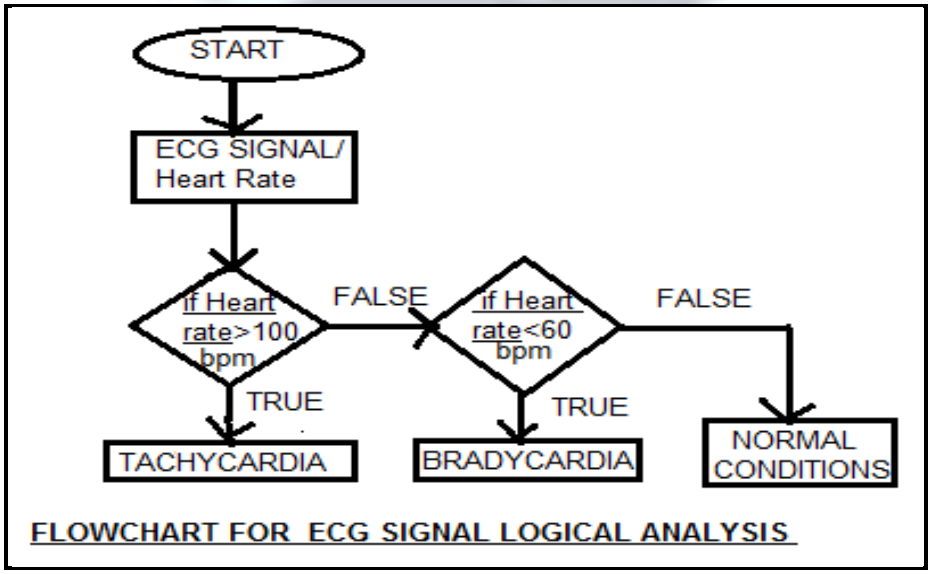


Fig: 5 Flow Char of Programming

F. Logical analysis:

Any indication of heart attack can be seen from R-R interval of ECG signal. So, BPM can be used to declare panic situation, if any indication of heart attack reflects on R-R interval. The indication of heart attack can be classified into two types. If the BPM becomes greater than 100 then it is situation of tachycardia and if it is less than 60 it is said to be bradycardia situation. BPM for normal person should range between 60 and 100. The micro controller declares a panic situation in the following cases.

- If the calculated BPM is greater than 100 or less than 60.
- If BPM is not same for every heart beat
- If amplitude of R-peak falls below the required for normal heart.



G. GSM module and transmission of signal in wireless medium:

For sending message to doctor and caretaker in case of panic situation we have used GSM SIM 300 module. After inserting SIM card of any GSM network it acts like a mobile phone of unique number. It works on attention (AT) command set. User can easily develop embedded applications of data transfer, SMS control, remote control and logging for this. It is connected to serial port of computer or microcontroller and used to send/receive SMS make/receive calls. It can be also used to connect with internet in GPRS mode. When microcontroller declares panic situation then according to code developed by us it sends command to GSM module to send panic condition alarm SMS to mobile phone of caretaker and doctor. After that microcontroller starts storing samples of a finite duration (we have stored ECG samples of 30 seconds) and after that duration it sends the samples of that duration through text message by GSM network established by GSM module to the doctor side or receiver side GSM module. It is nothing but transmission of digitalized values through SMS over a mobile cellular network. As a whole proposed model is a combination of all the above hardware put together. Below is the circuit layout of this design.

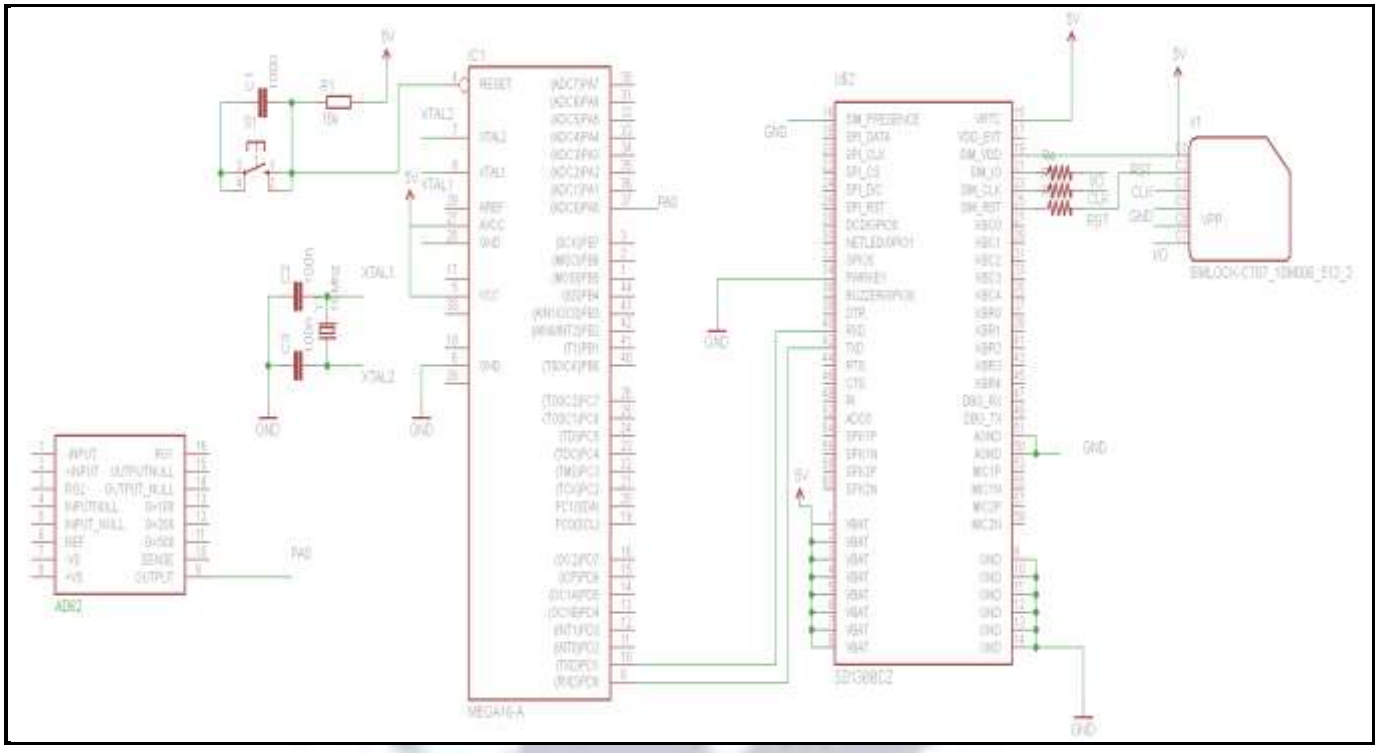


Fig 6: Circuit Layout of Design

3. ECG RECEIVER DESIGN

A. GSM and reception of ECG signal:

The ECG samples transmitted by transmitter side (patient side) GSM module are received by GSM module at receiver side (doctor side). This received digitalized value is directed by microcontroller to the PC using serial communication. USBTOTTL Bridge is used here for serial communication. It is used to connect TTL to RS232 signal to PC via USB for microcontroller. According to code developed by us in receiver side microcontroller an acknowledge message is send by receiver side GSM module to caretaker of patient to inform that the ECG samples has been received by doctor side system.

B. Plotting of received signal through MATLAB:

The digital data received at receiver side produce a real time plot using MATLAB on the computer screen [13]. The process goes like this data from a USB port will be read and plotted on a virtual oscilloscope. Microcontroller serves as a device that is used to write the received ECG signal to the USB port. Then using a simple MATLAB program we can continuously read and display the value from port automatically whenever signal is being received at the receiver.

RESULTS

The simplicity of our system really makes us to get the results in a very easy and comfortable manner. We have got satisfactory results from our system. As a whole we have to get the ECG signal to be processed in every step and as a result of these processing on the signal we get some new signal or data which is required later. The foremost result the ECG signal is acquired from the electrode and the waveform is checked roughly in DSO. The next step resultant signal is the amplified signal which is also checked-out in DSO. And we got the required gain as a result of amplification. As we were not having the patient when we were testing the system for the 1st time so we changed the coding little just to ensure for transmission of signal. We have set the range value for normal condition and we have tested through this that the proper transmission of signal is taking place.

The output signal transmitted to receiver is automatically obtained at the receiver. The signal received from GSM module is plotted on the screen. Hence the doctor can observe the ECG signal through the screen and can know the patient's actual condition and therefore our target is achieved. Along with all these results we are getting one more worthful result that is the message which is send to the caretaker's and doctor's mobile through GSM module of patient. Signal obtained at the receiver GSM module as a result is presented here by giving the snapshot of it. In addition to all the name of the medicine required by the patient's according to what doctor have suggested for them will be displayed with respect to the result of analysis. Like if result is stating the BPM is less than normal BPM rate the medicine for bradycardia will be displayed.

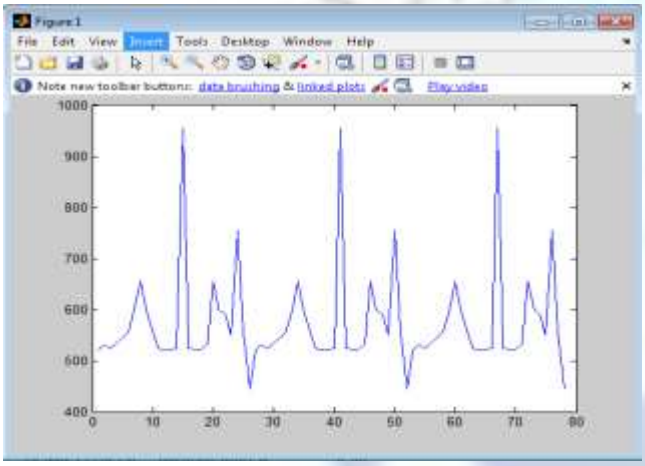


Fig: 7 (A)

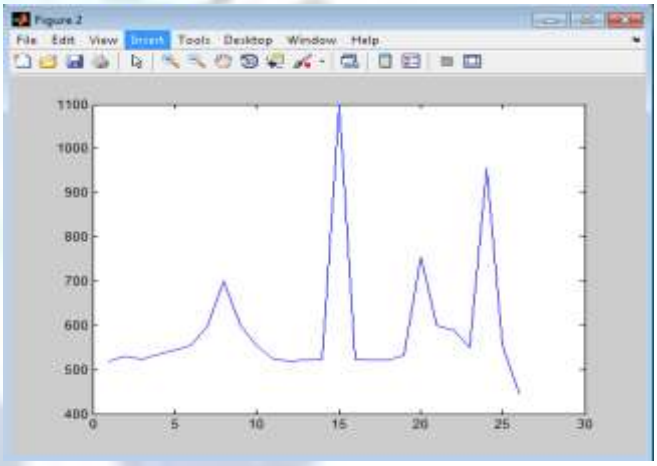


Fig: 7(B)

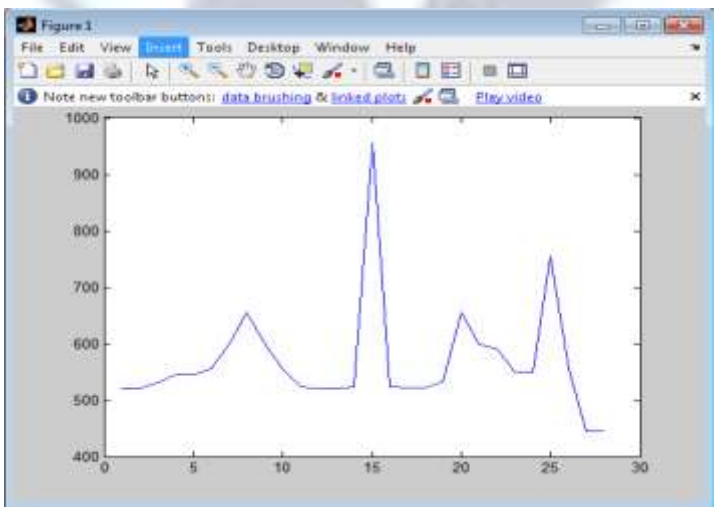


Fig: 7 (C)

Fig: 7 Signals Received At The Receiver

CONCLUSION

From all the above details and information about our system anyone can easily conclude the fact that our system is genuinely well-suited for the situation of cardiac patient along with the practical conditions in front of us. We must declare one more important unique feature of this system that is the system is of low cost. In addition to being low cost it is very much reliable since the transmission is in the form of messages not like other system in modulated signal or multimedia message form. One patient's device will cost at maximum of 2000 only which is affordable by common people and the doctor's unit is also around 2000 but since one doctor unit is for many patient so on particular basis the cost is very low.
The current state of the project should not be looked at, as a final product, but merely as a promising platform which will maintain enhancements within the design. With a continuation of the current design, the proposed end product is very realistic and attainable.

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