Wireless Cardiac Rhythm Monitoring System

Darshana Dineshkumar Darji[#1], Surbhi Prajapati[*2], Prof. Neelam Modi[#3]

[#]*Biomedical Engineering, Government Engineering College, Sector-28, Gandhinagar*

[1]darshana20994@gmail.com

[2]surbhiprajapati20@gmail.com

[3]neelamahmedabad@gmail.com

***Abstract*— An electrocardiogram (ECG), it is a very important parameter to detect arrhythmias. In this paper, we used AVR microcontroller-based system to detect heart rate. The main goal of our research proposal is to provide proper treatment in emergency situations. In our system, AVR microcontroller based health monitoring system is used to detect heart rate. In case of any abnormalities in patient's heart rate, our system uses wireless transmission of heart rate to the mobile phone of the physician through the GSM module. In case of any abnormal condition, message will send through GSM module to physician's mobile phone. Bases on experimental result we conclude that the system is friendly, small, and convenient.**

The aim of the research is to develop an Instrumentation system which helps to analyse and diagnose the abnormalities in the cardiovascular system. Development of the system includes electrodes for measuring ECG signals and comprising of instrumentation amplifiers and filters. Heart rate will be transmitted through a serial communication port to a wireless module GSM. In case of abnormalities situation signal will be transmitted using the cellular network to the doctor through GSM module. Then this transmitted data will be read by the physician. This method not only simplifies and speeds up the process of information acquisition, processing, but also declines the cost of equipment as well as help doctors to keep track of their patient's condition easily.

Keywords*— *Instrumentation System, ECG signals, GSM module, Cellular network, Acquisition

I. INTRODUCTION

Amazing Industry and economic growth are leading for complex and difficult daily life stress, anxiety, disturbance of many people[1]. The disease is not infectious but a cardiovascular disease illness that exponentially increases medical expenses. In recent years, The remote medical information system is used.[2] It becomes increasingly intrinsic. Especially the system is used for care, not only conducts but we will provide better health control, medical expenses. Heart disease in today's world continues to be a threat to human health. The measurement of the biological signal of the patient is very Important factors for cardiac diagnosis. Among the various devices to measure, Detection of heart disease, ECG is preferred for this accuracy, convenience, low cost.

There are several options. Norman Jefffer Halter in 1957, the "Holter monitor" was hardware and Software to register the ambulatory ECG. The telecommunication branch is expanding rapidly. ECG now monitors by using Smartphones and Wi-Fi, Internet solution, Bluetooth for advertising Analysis. The protocol has the following disadvantages: (1) the required electrode Attached to the chest to detect ECG follow-up, (2) high cost, (3) delay in detection & analysis of ECG, (4) high Energy consumption, etc.[1] With many advances Change in the field of mobile equipment Telecommunications led to the growth of mobile devices data service by supporting the cellular mobile system Promote the expansion of new Application.

2006 [3]Author Peter Leijdekkers, Valerie told that High cholesterol, hypertension and the lifestyle of diabetes and obesity is authoritative for Cardiovascular disease. "Holter device" is conventional Cardiac monitoring solution used by cardiologists & for Analysis of ECG of patients. When using this device at home, It is your normal activity, in case of abnormalities, this device is not offer any action. However, several changes were introduced J. Rodrigues, to solve this problem. It is classified into two groups.[4] A smartphone equipped with a biosensor is the first group to accept patients sent to heart parameters through the GSM module to the physician. There are few solutions that can be transmitted wirelessly ECG data stored using GPRS to the health center Mobihealth [5] actually refers to remote monitoring. These solutions monitor the vital signs of the patient using Portable wireless sensor. This project will develop intellectual biomedicine, Clothes for control, diagnosis and treatment of the heart with patience.

To alleviate this problem Amon project process the ECG data in the local device for remote data processing [6]suggested to use the vigilant and surveillance system for high-risk heart patients. This intelligent system collects and evaluates vital signs and for ECG monitoring. The disadvantage of system is that acquired ECG signal has too much noise and not consider for the diagnosis of cardiac disorder. The Epimedicproject [7] provides a smart ECG monitor for recording, analysis of electrocardiogram signals with alert alarm. It cannot periodically monitor as a cardiologist's suggestion but it can be customized.

In our work, the goal is to study, to conceive and make a wireless system that uses the INA128 instrumentation amplifier to amplify the ECG signal and filter is used to remove baseline noise than heart rate is detected. Bases on heart rate, message have been sent through GSM module to Physician. ECG clamp electrodes is used to record ECG signal of heart patients. The system will diagnose and collecting information than processing it then passes it wirelessly via GSM module to physician or any other person. The patients are informed about life-threatening arrhythmias and about the health of the patient and if a critical situation is observed, then information pass through on doctor's mobile device with the SMS alert.

II. DESIGN COMPONENT

The proposed system is the wireless cardiac rhythm monitoring system for cardiac arrhythmia includes hardware and software.

Required Hardware

1) Signal amplification & filter unit

The ECG signal which uses INA 128 Amplifier with high performance. The original raw ECG signal is inappropriate. INA128 is low Noise Amplifier and highly accurate Instrumentation Amplifier. Due to all these features, INA 128 can be used for high speed data Acquisition system. Filter circuit is used to remove noise from ECG signal.

2) Microcontroller

The Atmega 328 is a microcontroller with a chip created by Atmel and belongs to the mega AVR series. The Atmega 328 is used in areas where simple, low cost microcontrollers are required. The general application of this chip is in the general platform Arduino development.

3) GSM Module:

GSM (Global System for Mobile) is a device that the SIM 900 devices operate at 850 MHz, 900 MHz, 1800 MHz and 1900 MHz frequencies.

The modems are designed so users can interface directly with 5V microcontrollers (PIC, AVR, Arduino, 8051 etc.).

It is suitable for mobile phone data transfer applications as well as for an SMS interface on a mobile phone.

Required Software:

Arduino IDE software is used to do Programming of the system.

III. IMPLEMENTATION OF PROPOSED SYSTEM

1) Block diagram of proposed system

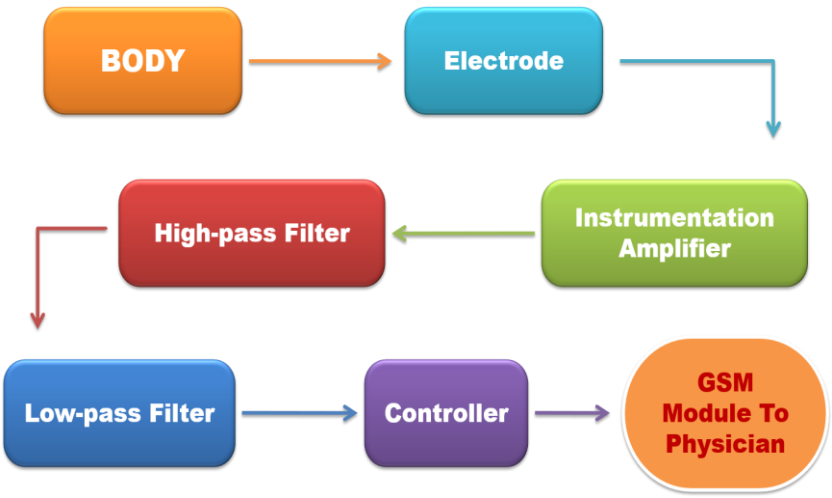

Figure: Block Diagram of Proposed System

a) ECG electrodes

Electrodes as electrocardiographic accessories applicable to most electrocardiograph devices. It can be connected to the banana jack and button connector, clip is made of special material to increase elasticity.

Figure: Clamp Electrodes
Source: https://www.hospinet.com.

Description:
-Adult limb clamp Ag / AgCl electrode, clone pin type
- 3.0 mm diameter or 0.156-inch snug fit. (4 mm) Banana Plug or (4 mm) snap wire.
- Metal electrode: Ag / AgCl
- I box = 4 electrodes

b) INA128 instrumentation amplifier

INA128 and INA129 are amplifiers with low power general purpose instruments and provide excellent precision. The 3 Amplifier design and miniature design make it ideal for a wide range of applicationsWith a single external resistance, a gain of 1 to 10,000 is set. INA 128 provides a standard gain formula. The gain expression of INA128 is compatible with AD620. In our mechanism, I set 1000 gain for amplification of ECG signal.

c) High pass filter

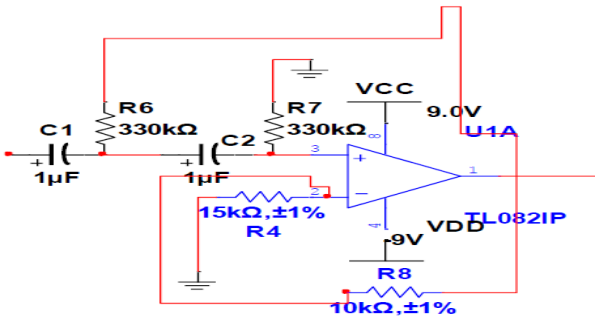

Figure: Schematic Representation of High pass filter

We have design a high pass filter with 0.5 Hz frequency. The reason of using this filter is to eliminate most of the DC offset in acquired Signal.

Calculation:

C = 1µF

F_H = 0.5 Hz

R = $1 \div 2\pi FC$

= $1 \div (2) * (3.14)(0.5)(1 * 10^{-6})$

= (0.3184)*(10^{-6})

= 318 KΩ

R $\approx 330\ K\Omega$

R_1 = 15 KΩ

R_F = 10KΩ

R_L = 10 KΩ

d) Low pass filter

We have design a low pass filter with cut off frequency of 150 Hz. The reason of use of this filter is to eliminate frequencies which is higher than 150 Hz and to remove noise.

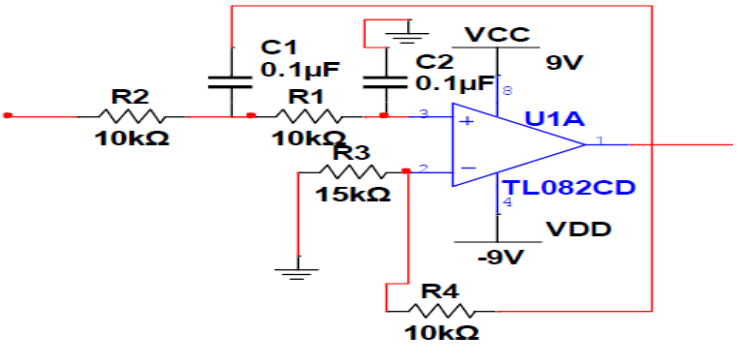

Figure: Schematic representation of low pass filter

Calculation :

F_H = 150 Hz

$C_1 = C_2 = 0.1\mu F$

$$F = \frac{1}{2\pi RC}$$

$$= \frac{1}{2\pi\sqrt{R1}*\sqrt{R2}*\sqrt{0.1}*\sqrt{0.1}*\sqrt{10^{-12}}}$$

$$= \frac{1}{2*3.14*\sqrt{R}*\sqrt{R}*\sqrt{0.01}*\sqrt{10^{-12}}} \quad (R1 = R2)$$

$$= \frac{1}{0.628*R*\sqrt{10^{-12}}}$$

$$150 = \frac{10^6}{0.628\,R}$$

$$R = \frac{10^6}{150*0.628} = 10.6K\Omega$$

$$R \approx 10\,K\Omega = R_1 = R_2$$

Let R3 = 15 KΩ

C_1=C_2= 0.1 µF

$R_F = (0.586)*R3$

$= (0.586)*(15*10^3)$

$R_F \approx 10K\Omega$

e) Notch Filter

We have design a notch filter with a frequency 50 Hz. This filter is very important because of unshielded leads is used for acquiring ECG signal. The reason of use of this filter is to remove the base line noise from the signal.

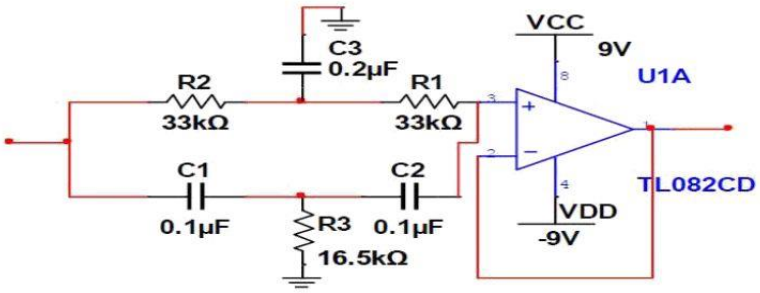

Figure: Schematic representation of Notch filter

Calculation:

F = 1/2πRC

F = 50 Hz

C = 0.1* 10^{-6}

$$50 = \frac{1}{(2)*(3.14)*(R)*(0.1*10^{-6})}$$

$$R = \frac{1}{(2)*(3.14)*(50)*(0.1*10^{-6})}$$

R = 0.031847*10^{6}

$R \approx 33\ K\Omega$

f) AVR controller

The 8-bit High Performance Microchip AVR RISC microcontroller combines 32KB ISP flash memory with read-write functions, 23 general purpose I / O lines, 1KB EEPROM, 2KB SRAM, 32 general purpose work registers, three timers flexible / counters with comparison modes, internal and external switches, 6-channel 10-bit A / D converter (8 channels in TQFP packets and QFN / MLF), USART programmable serial, 2-wire serial interface, serial port SPI, programmable watchdog timer with internal oscillator and five software selectable power saving modes. The device operates between 1.8-5.5 volts.

g) GSM Modem

Just like mobile phones, GSM modem does not have any keypad. It works on AT commands using serial interfacing. Each of command is started with AT, that is the reason they called as AT commands. AT means attention. In our system, the program waits for the mobile number to be entered through the keyboard. When a ten-digit mobile number is provided, the program instructs the modem to send the text message using a sequence of AT commands.

2) Principle of operation of ECG

This could be an electrical contractile activity of the heart. It is recorded quickly and automatically. It is non-invasive Diagnostic tool. The electrode is placed on the chest. The patient's skin detects the bio-potential given by the heart reaches the surface of the skin for measurement. The position of the chamber and the presence of damage to the heart, Indicates cardiovascular disease information. The ECG turned the electrical activity of the heart into a line Paper Tracking. In medical examination, heart disease detection is based on the difference in wave signals appears on the screen during the ECG test.

ECG Sensor: Three wires are used. The potential difference is recorded by Placing electrodes on the body surface, signals are too low so that INA128 instrumentation amplifier is used to amplify the ECG signal. The instrument amplifier is applied to the high pass filter of 0.5 Hz. Than output of high pass filter is applied to low pass filter of 150 Hz. Than output of low pass filter is applied to Notch filter of 50 Hz. Than output of Notch filter is given to analog pin of AVR microcontroller.

The most commonly used method of electrode positioning is described in below.

Lead I: left arm right arm,
Lead II: right leg left leg,
Lead III: left arm left leg

3) Interpretation of ECG signal

Interpretation of electrocardiogram: heart rate, A sinus bradycardia with a pulse rate less than 60 bpm and Tachycardia with a pulse rate greater than 100 bpm can be mentioned. After that, Calculation of ECG parameters such as QRS complex, wave T, wave Q, normal pulse rate is 60, Maximum 100 bpm. Different types of arrhythmia may be detected. It is based on irregularity of PR and QT interval. The proposed system forwards the diagnostic data to the physician's smartphone through GSM module.

Hardware Design :

Hardware was made on GPB (General Purpose Board) as shown in figure below:

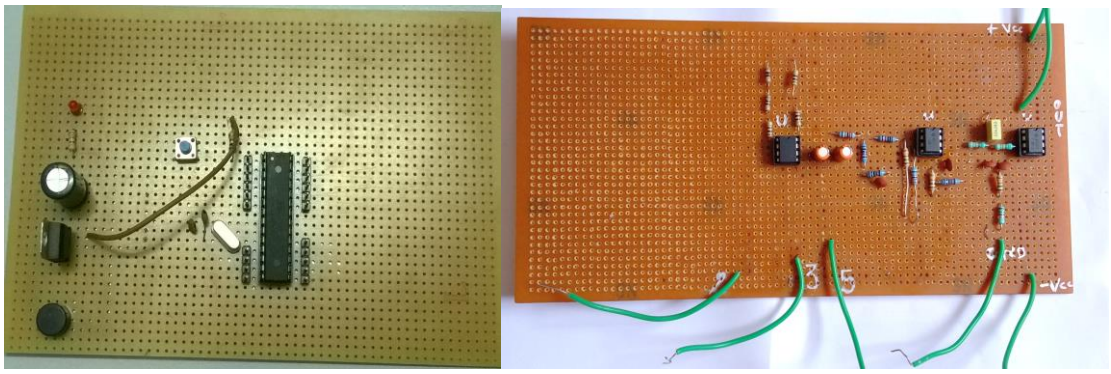

Figure: AVR microcontroller basic circuit and High pass, Low pass & Notch filter Circuit

Output on DSO (Digital Storage Oscilloscope):

After completion of Designing, we got ECG signal as shown in below figure by using DSO.

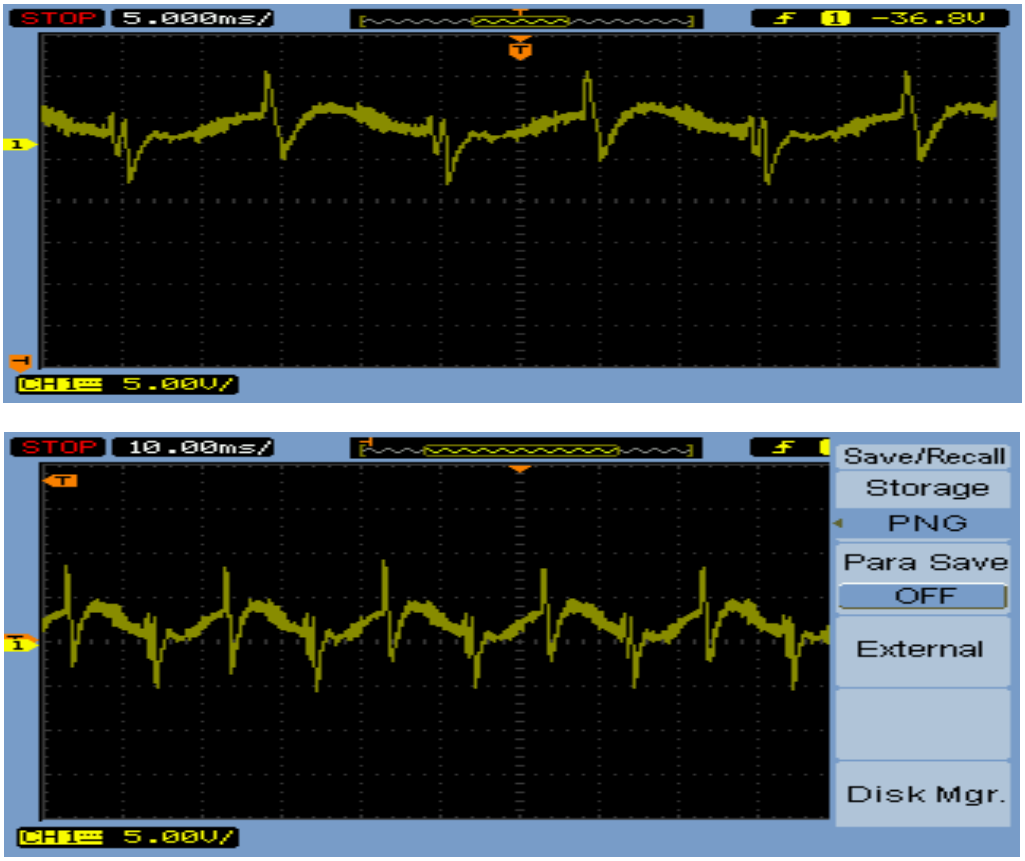

Figure: Output of acquired ECG signal on CRO

Output on Mobile Phone:

Wireless transmission of message to physician in smartphone as shown in figure below:

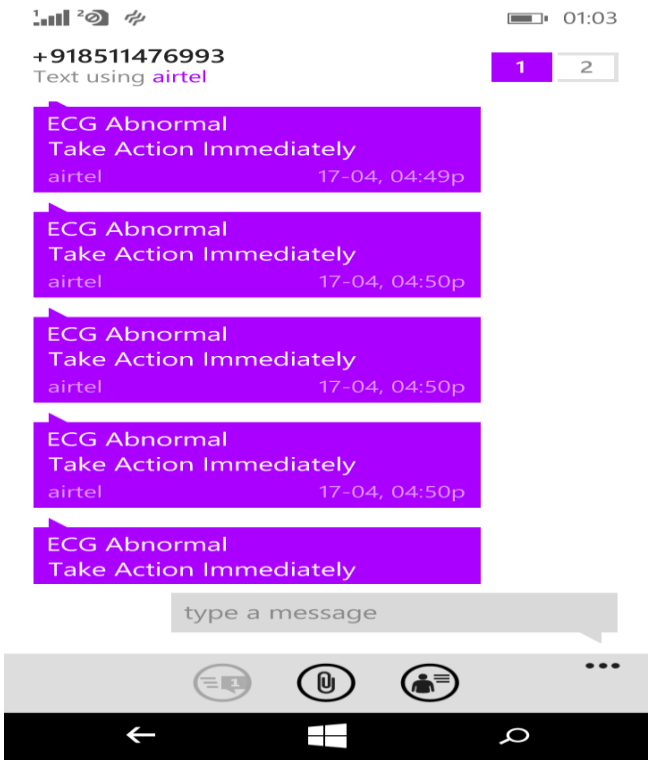

Figure: Message on smartphone

Advantages:

1) It is low power consumption and smartphone-based ECG monitor system.
2)You can monitor using this system Cardiovascular disease due to wireless connection.
3)Communication such as provided information is reliable, so it can be used in critical environments.
4)Prerequisites for issuing an alarm and starting early First aid Since the result can be seen on the smartphone, you can inspect ECG anytime, anywhere improve medical quality.
5)Wireless system is built into the system and send patient's heart rate data to mobile phone using GSM module.

The suggested system is that the doctor can identify different arrhythmia condition of patient's according to heart rate using own handheld device. The above advantages can be realized by a small user Easy to use, cost-effective devices can revolutionize Patient 's heart care.

IV. CONCLUSION

The our wireless cardiac rhythm monitoring system including instrumentation amplifier, filter circuit, AVR microcontroller and with the help of GSM module to the physician’s mobile phone. The proposed wireless system is light weight, compact, low cost, precise. Patient’s ECG signal taken and heart rate can be detected and bases of heart rate arrhythmias can be detected. Message of normal/abnormal condition of patient can be easily transmitted to the physician. Physician can take immediate action and advise the patients possible treatment.

V. FUTURE WORK

Over the course of the research work, many features and potential improvements were discussed. Some of the improvement are listed below.

- Hardware Improvement – PCB

  Printing the circuit to a PCB with ground planes would reduce some noise in the system and would allow for a much smaller product. Because of how little circuit is actually involved, a printed circuit board with surface mount components would be very small.

- Power Supply

A better battery system would need to be developed before the hardware portion of this system could be brought to market. An accurate power supply would be useful for bulk production of hardware.

REFERENCES:

[1] Z. Shi, Z. Jinshuan, S. Lihuang, and W. Guohua, "A novel pocket intelligent one lead ECG monitor based on fingers touching," *Proc. 2009 2nd Int. Congr. Image Signal Process. CISP'09*, pp. 1–3, 2009.

[2] Vitaphone, "No Title." [Online]. Available: http://www.vitaphone.de/us-en/home.html.

[3] P. Leijdekkers and V. Gay, "Personal heart monitoring system using smart phones to detect life threatening arrhythmias," *Proc. - IEEE Symp. Comput. Med. Syst.*, vol. 2006, pp. 157–162, 2006.

[4] J. Rodríguez, A. Goñi, and A. Illarramendi, "Real-time classification of ECGs on a PDA," *IEEE Trans. Inf. Technol. Biomed.*, vol. 9, no. 1, pp. 23–34, 2005.

[5] S. Laxminarayan *et al.*, "This Technical Report is also published as Chapter 16 IN M-Health : Emerging Mobile Health Systems, Robert H . ISBN : 0-387-26558-9 As MOBIHEALTH : MOBILE HEALTH SERVICES BASED ON BODY AREA NETWORKS MOBIHEALTH : MOBILE HEALTH SERVICES BASED ON BODY AREA ," 2006.

[6] U. Anliker *et al.*, "AMON : A Wearable Multiparameter Medical Monitoring and Alert System," vol. 8, no. 4, pp. 415–427, 2004.

[7] P. Rubel *et al.*, "Toward personal eHealth in cardiology. Results from the EPI-MEDICS telemedicine project," *J. Electrocardiol.*, vol. 38, no. 4 SUPPL., pp. 100–106, 2005.