A Cardiac Telemonitoring System

[1]V S Waydande , [2]Prof. A N Jadhav
[1](*Dept of ETC /Dr D Y Patil College Of Engineering , KolhapurIndia*)
[2](*Dept of ETC /Dr D Y Patil College Of Engineering , KolhapurIndia*)

Abstract-*In the present work we have made an effort to provide help and rescue the cardiac affected patients, by building a system that enables transmission of patient's ECG, in the real-time, to be diagnosed by an expert cardiologist, through wireless means. It helps cardiac patients, in getting the medical help just in time, under emergency. It can also be used for the patients who have been discharged from the hospital, or on those patients, who have been kept on observation, to send ECG signals on a regular basis to alert the concerned doctor or the other medical staff. One of most important advantage of ECG monitoring by this system is, it detects serious emergency condition before they prove dangerous. It supports 24 hours patient care and saves the time required for transporting the patient to the hospital.*

I.   INTRODUCTION

Now-a-days Heart related diseases are on the rise. Worldwide surveys conducted by World Health Organization (WHO) have confirmed this. Many of cardiac related problems are attributed to the modern lifestyles, food habits, obesity, smoking, tobacco chewing and lack of physical exercises etc.

The post-operative patients can develop complications once they are discharged from the hospital. In some patients the cardiac problems may re-occur when they start doing their routine work. Hence the ECG of such patients needs to be monitored for some time after their treatment. This helps in diagnosing the improper functioning of the heart and take precautions.

An ECG is a measurement of the electrical activity of the heart muscle as obtained from the surface of the skin. As the heart performs its function of Pumping blood through the circulatory system, the result of the action potentials responsible for the mechanical events within the heart is the generation of a certain sequence of electrical events.

1. ECG Measurement

The electrical impulses within the heart act as a source of voltage, which generates a current flow in the torso and corresponding potentials on the skin. The potential distribution can be modeled as if the heart were a time-varying electrical dipole if two leads are connected between two points on body, electrical voltage observed between the two electrodes is given by the dot product of the two vectors.

2. System Functionality

The key task is to design simple wireless ECG Monitoring system. It will be first electrocardiogram monitoring system to eliminate the wires and cables between patient's and bedside monitors. RF technology will transmit data from electrode to system. The system helps in giving early mobility to patients. The device component will be designed to make them appear more comfortable to wear. Therefore, it has designed our solution with patient mobility in mind to facilitate mobile monitoring, which enables personalized home based monitoring where patient can access their health records anytime anywhere.

II.   ECG- an Overview

1. Heart Signal

The atria and ventricles work together, alternately contracting and relaxing to pump blood through heart. The electrical system of the heart is the power source that makes this possible. Heartbeat is triggered by electrical impulses that travel down a special pathway through the heart. The impulse starts in a small bundle of specialized cells called the SA node (sinoatrial node) , located in the right atrium. This node is known as the heart's natural pacemaker. The electrical activity spreads through the walls of the atria and causes them to contract. At rest, a normal heart beats around 50 to 99 times a minute. Exercise, emotions, fever and some medications can cause your heart to beat faster, sometimes to well over 100 beats per minute.

2. Electrocardiogram

ECG is the electrical manifestation of the contractile activity of the heart's myocardium. The P, QRS and T waves characterize the ECG waveform. The most prominent feature is the QRS complex, where R denotes the peak of QRS complex (Fig 2.1) Any disturbance in the regular rhythmic activity of the heart (amplitude, duration and shape of rhythms) is known as arrhythmia. Cardiac arrhythmias may cause the heart to pump less effectively, causing insufficient blood to reach the brain another vital organ. When the body's blood flow is inadequate, the person can faint or suffer chest pain.
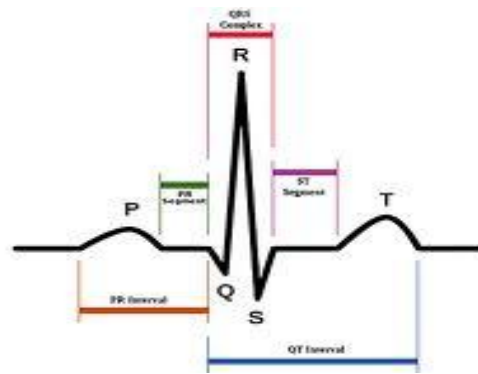

fig 2.1   ecg waveform

3. Standard ECG Lead System

Two electrodes placed over different areas of the heart and connected to the galvanometer will pick up the electrical currents, resulting from the potential difference between them. The resulting from tracing of voltage difference at any two sites due to electrical activity of the heart is called a "lead". Most of the ECG machines use 12-lead system, whereas in this project a 3-lead system is used. Both feature 3 electrodes placed on the limbs. If the heart's electrical activity is viewed as a simple dipole, these three leads record the projection of this dipole onto the sides of the 'Einthoven Triangle' i.e. the equilateral triangle formed by the vectors of the limb leads.

4. Common Artifacts

The electrical signals of heart obtained from the patient's body are of very low strength (2.5mV) and mixed with noise. The instrumentation amplifier and further amplifier amplify the low strength signals to provide gain up to 500. Three different types of noise are present in the signal.
 1. DC Electrical offset potential
 2. 50 Hz AC induced interference
 3. The electrodes pick up muscular noise.

III.   SYSTEM DESIGN

 The electrical signals of heart obtained from the patient's body are of very low strength (2.5mV), low frequency and mixed with noise. The instrumentation amplifier amplifies the low strength signals and filters eliminates the noise. Using notch filter eliminates the 50 Hz supply noise picked up by body. ADC then converts the amplified clean signal into digital samples. The micro controller takes care of acquiring the samples and storing them in memory. The data acquired from memory is converted into serial data and transmitted through Com 1 port to transmission module. The reception module receives the data and transmits it serially to computer through Com 1 port. The data is represented in graphical format on computer. Block diagram of the system in fig 3.1.
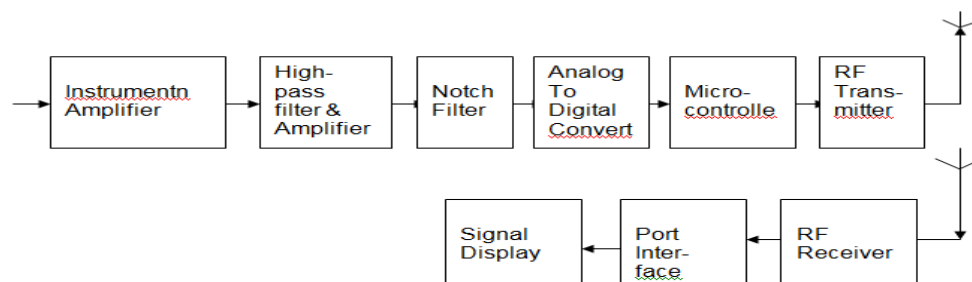

Fig 3.1 block diagram of system

1. Instrumentation amplifier

This is intended for low level signal amplification where low noise, low thermal and time drifts, high input impedance an accurate close loop gain are required. Besides, high CMRR and high slew rate are desirable for superior performance. As ECG signal is of very low amplitude instrumentation amplifier is used to amplify it at initial level so that ECG signal will not get loaded. The two signals entering the differential amplifier are subtracted to cancel the common noise present in the signal. Because of instrumentation amplifier common noise gets cancel with advantage of strengthening the signal. AD 620 is used as instrumentation amplifier with gain set to 50

2. High pass filter and amplifiers

In order to block DC offset present in the signal, we have to use High Pass Filter . If DC is not getting blocked at this level It will increase with gain of amplifier connected after DC blocker, will induce noise. In order to provide gain of 500 we have to use amplifier of gain 10 after High Pass filter.

3. Notch filter

In order to reduce 50 Hz power line frequency hum notch filter is very essential. It should be highly precise at 50 Hz. It is composed of one low pass filter to blocks, and one high pass filter.

4. Microcontroller

For our project we are going to microcontroller AT 89C52. This controller is for controlling analog to digital converter operations, MAX232 is used for serial interface and controlling the wireless communication through Si 4432. Programming of the microcontroller is done in C language code.

5. Analog to Digital Converter

For converting analog signal of ECG into digital in order to interface with the microcontroller analog to digital converter is needed.We used ADC 0804. It has several features, which are useful for us. Conversion time is very less. It gives parallel 8 bit output, makes it easy to interface with the microcontroller.

6. wireless communication kit

The system uses wireless communication kit Si 4432 for transmission of digitally converted ECG signals. Transmitter current drawn is very less in this case. Maximum data rate is 9600 bits per second. The range of the module is of >600 meters. The low power consumption of the module makes it perfect for the portable devices.

7. Signal Display

In practice paper recorder are used to display the variation in the electric activity of the heart. The ECG is printed on the graph paper. This system display ECG signal , on monitor of computer. Digital signals are captured from RS232 port and displayed by using software, which is written in VB.

IV.   SOFTWARE DESIGN

1. Microcontroller Unit

Software for the microcontroller is designed in C language. Before writing a program, modes of serial communication is decided, baud rate is selected. Conversion is initialized by sending pulse of Start of conversion. After waiting up to conversion time and accepting End of conversion, 8-bit data is read from ADC. 8 bit data is transmitted to SBUFF register. Hex code generated is burned in to 89C52 using the Keil software. This program will continuously collect the values from ADC and transmit to the wireless module. Wireless module converts it into 433.33 MHz frequency using GFSK technique.

2. PC serial port

The RS-232 serial communication standard is the most popular serial communication scheme in the world. Although it suffers from many drawbacks, speed being the primary one, it use is wide spread and there are literally thousands of devices you can connected to a PC using an RS-232 interface. Manipulating the serial port is not difficult

V.   RESULTS AND CONCLUSION

This wireless device is designed to record single channel of full-spectrum ECG. It can monitor ECG of a patient, who is far apart. The device analyzes ECG for real time and will display heart rate, amplitude, and intervals of some critical components. The system consist of two section-
1. Transmitter
2. Receiver

1. Transmitter

ECG signals capture by Electrode are processed and filtered by signal conditioning block. Filtered signals are given to ADC 0804 for conversion into 8-bit digital data. Digital data is transferred to the MAX 232 using microcontroller. Si 4432 Wireless communication kit collects data from Max232, which then modulates it using GFSK technique and transmit at a frequency of 433.33MHz.

2. Receiver

At the receiver side we have receiver of Si 4432 Wireless Communication Kit and PC to display waveform. Si 4432 will receive data at 433.33 MHz, demodulate it and transfer it to the COM I port of PC. At receiver Heart rate, R-R interval, R-Wave amplitude is calculated and displayed on screen.

Results

Wireless ECG Monitoring System is tested on Five persons. ECG signals are observed on monitor of computer. It is observed that they are comparable. Comparison of parameters obtained from ECG Machine and Wireless ECG Monitoring System:

Table 5.1: Comparison of parameters

Sr. No	Parameter	Observation using ECG Machine	Observation using Wireless ECG
1	R-R interval	0.560 msec	0.636 msec
2	Heart rate	85 per minute	90 per minute
3	R wave amplitude	1 m V	0.8 mV

Conclusion

Based on the results presented above it is concluded that:

1. Wireless ECG monitoring system is designed and implemented successfully.

2. The performance of the system is satisfactory and it's validity is certified by physician.

3. This system can acquire ECG signals of patient present at remote place (200m) and the   signals can be recorded and analyzed at receiver side.

4. The system is tested for 5 normal persons and results are compared with ECG machine results and accuracy found in 85%

5. Accuracy is limited due to conversion time of ADC used.

6. The system can measure ECG parameters like R-R interval, Heart Rate, R-wave amplitude in real time.

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