ECG Monitoring and Real-Time Wireless Transmission System for Ambulance

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***Abstract*—**: ECG is the most vital parameter, and it gives information about the current condition of the patient. The ECG measuring instruments available today are of high cost and hence there is a need to build an economical system. The patient has to be continuously monitored and the data has to be immediately sent to the doctor in the hospital to analyze and suggest any first aid, which will help the crew in the ambulance to take necessary action according to the doctor's suggestion. Also, the doctors at the hospital are informed of the severity of condition of the patient and hence can make appropriate preparations for the treatment, particularly in cases of life-threatening medical conditions like circulatory shock. Thus, in this project we have built ECG monitoring system to process the ECG signal in the ambulance and have used zigbee wireless communication to transmit the signal to the hospital server.

Keywords- *ECG, Zigbee, SNR, FIR filter, circulatory shock*

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I. Introduction

Electrocardiography (**ECG)** is the recording of the electrical activity of the heart. Processing of the ECG signal using digital filter involves initial sampling of the signal from electrodes on the body surface. Next, the digital ECG must eliminate or suppress low-frequency noise that results from baseline wander, movement, and respiration and higher-frequency noise that results from muscle artefact and power-line or radiated electromagnetic interference .Circulatory shock, commonly known as shock, is a serious life threatening medical emergency and one of the most common causes of death for critically ill people. If the degree of shock is informed to the medical staff, they can make preparation to handle the situation. During emergencies, common ambulances (except for very sophisticated, in turn, very costly) will not have the equipments that can monitor the patient's condition. Our system can monitor the patient and send the report to the hospital. In recent times, Wireless sensors and sensor networks have become areas of great interest for research, scientific and technological community.The potential created by the heart wall contraction spreads electrical currents from the heart throughout the body. The spreading electrical currents create different potentials at different points on the body. Leads are placed on the body in several pre-determined locations to provide information about heart conditions. The cardiac signal, typically 5 mV peak to peak, is an AC signal with a bandwidth of 0.05 Hz to 100 Hz . The ECG signal is characterized by six peaks and valleys labeled with successive letters of the alphabet P, Q, R S, T, and U (Figure 1).

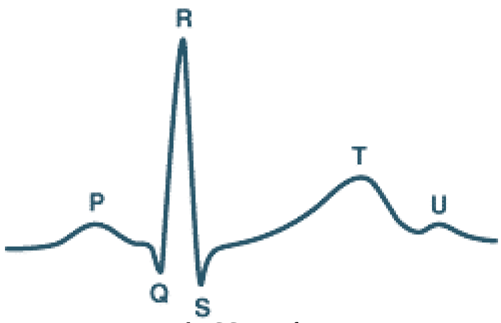

Figure 1: Typical ECG waveform

II. Brief Literature Survey

In this hectic and polluted world taking care of health is necessary to live healthily particularly patients with heart problem. Cardiovascular disease is the world's leading killer, accounting for 16.7 million or 29.2 per cent of total global deaths With modernization, a large proportion of young people are trading healthy traditional diets for fatty foods. Also most of them are employed with deskbound sloth nature of jobs that lacks any physical exercise. They also lead a stressful city life when compared to the relative calm of the countryside. Here we are distinguishing between the existing and proposed system of ECG monitoring machine.

Existing systems:

- People faces much financial and society pressure .
- Difficult to monitoring of health status.
- Causes the heart to be less efficient.
- Recorded data to be time dependable.

- Limited distance between monitoring and person.

Proposed systems:

- Effective way of communication technologies.
- Portable ECG health monitoring.
- Data storage and transmission format are conformed to IEEE 1073 point-of-care Medical device communication standards.
- Efficiencies of rescuing are increasing. Monitoring for the user at any time and any place.

Hence we propose a telemedicine system that monitors, performs real time analysis with the mobile phone and alerts the physician about the fatal condition. Also both the patient and the doctor can be mobile. This system maximizes the ability of cardiac patient to regain their independence and move freely [2].The aim is to outline the major new health uses of these technologies, what is this technology, describe the technologies, and provide a guide covering the key principles in this technology [2]. Information technology can be an important tool for empowering people and enabling them to be more productive and effective in their work. It can also be a tool that exacerbates division and inequality by creating sections of the community which are information-rich and others that are information-poor. The aim of telemedicine developments should reflect this. Telemedicine should always aim to support health workers providing care as close to the patients as possible [4]. To find the RR interval of the PQRS wave, the fact that the R wave is the most sharp, narrow and steep section of the wave, will be exploited. Moreover, the R section of the wave is the most sensitive one and any heart irregularity will instantly reflect on the R wave with great prominence [2].

III. MOTIVATION

The current biomedical devices require a certified doctor at the patient's location but our system requires only a paramedic who can take necessary actions .In the system we have designed, the doctor can handle many cases at a time and give necessary instructions to the respective paramedic which will be saving the doctor's ample amount of time. This system can be used for future healthcare applications in home-care-sensor network where wireless link is used to transmit real time medical information to improve medical quality of surface.

IV. PROPOSED SOLUTION AND IMPLEMENTATION

As the aim of this study is to build an accurate ECG system[8] and transmit the acquired data at minimum cost, RF modules like Xbee can transmit data up to the range of 50km and the transmission would be free of cost if once the modules are installed thus we have used xbee modules to transmit and receive the data. The project is mainly divided into four sections namely analog front end design, digital signal processing, transmission and reception. Analog front end design includes design of instrumentation amplifier followed by high pass, low pass and notch filter. Digital signal processing also includes implementation of high pass, low pass and notch filters on arduino due board. In the transmission phase we transmit data using XBee module. In the reception phase data is received using xbee module and the output is plotted using plotting java processing software. Figure 2 depicts the block diagram of ECG implementation.

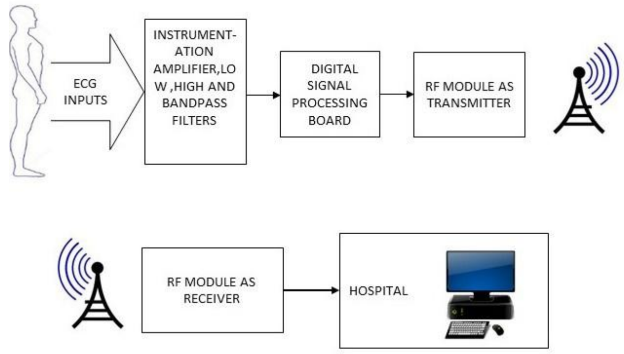

Figure.2 Block diagram of ECG Implementation

A. *Details of analog front end design*

This is a 3 lead ECG design in which 2 disposable electrodes collect the ECG signal and another one is used as reference electrode. Signals from the electrodes are passed into the instrumentation amplifier [5] having a gain of 1000 and CMRR of 100 db. The right leg reference electrode provides reference voltage for the instrumentation amplifier.

The output of the instrumentation amplifier circuit[1] is passed into the fourth order Sallen key high pass filter with cut-off frequency 0.05 hertz according to the requirements of IEC. The output from high pass filter is passed into the fourth order Sallen key low pass filter with cut-off frequency 100 hertz according to the requirements of IEC. The output of low pass filter is passed to the notch filter with cut-off frequency of 50 hertz.

B. *Digital filter implementation*

The digital filtering system consists of arduino due board with specifications [6] to implement digital filters. Three filters are designed in digital domain using FDA tool [2] in MATLAB [10] and the filters are implemented using convolution where g[n] represents filter coefficients and f[n] represents input sampled signal.

$$(f*g)[n] = \Sigma f[n-m]g[m] \quad -m \leq n \geq m \ldots\ldots. (1)$$

High pass FIR filter is designed using kaiser window [11] with order 25, beta 2 and cut-off frequency 0.05 hertz. Low pass FIR filter is designed using kaiser window [11] with order 50, beta 2 and cut-off frequency 100 hertz. Notch FIR filter is designed using Kaiser Window [11] with order 50, beta 0.01 and cut-off frequency 50Hz.The plot of ECG waveform using MATLAB is shown in figure 3.

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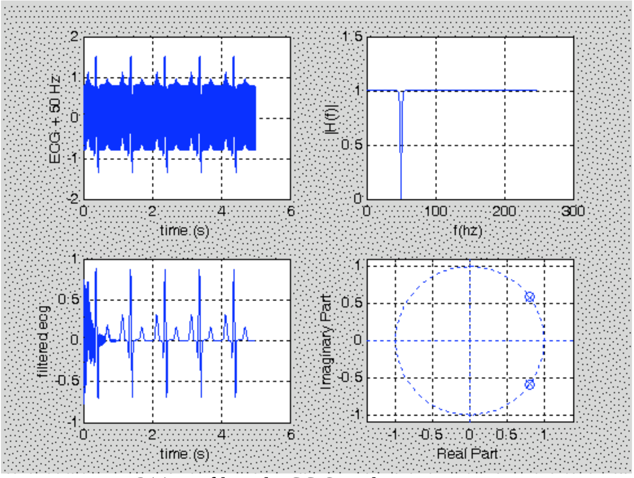

Figure 3(a): Unfiltered ECG Signal
Figure 3 (b): Notch Filter Magnitude Response
Figure 3(c): Filtered ECG Signal
Figure 3(d): Pole-Zero Diagram

V. COMMUNICATION

XBee is a low power, long range module based on the 802.15.4-2003 standard designed for point-to-point and star communications at over-the-air baud rates of 250 kbit/s and transmit power of 22dBm. Xbee [4] can operate either in a transparent data mode or in a packet-based application programming interface (API) mode. In the transparent mode, data coming into the Data IN (DIN) pin is directly transmitted over-the-air to the intended receiving radios without any modification which is used in our system. Output of the digital processing unit is sent to XBee module which transmits data to its paired RF module at receiver and the RF module used is TARANG P20[7]. The module operates at 2.4GHz with IEEE 802.15.4 baseband having a range of 1km line of sight. For further larger distance communication RF modules of more than 50km range are available.

VI. RESULTS

The below figures shows the ECG wave (fig.4) and Temperature (fig.5) is displayed on the screen. The ECG wave is plotted using MATLAB and JAVA software, here we showed the plot by using JAVA plotting software.

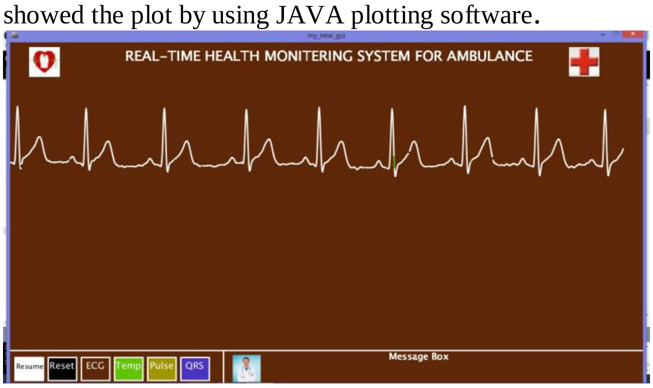

Fig. 4 ECG wave

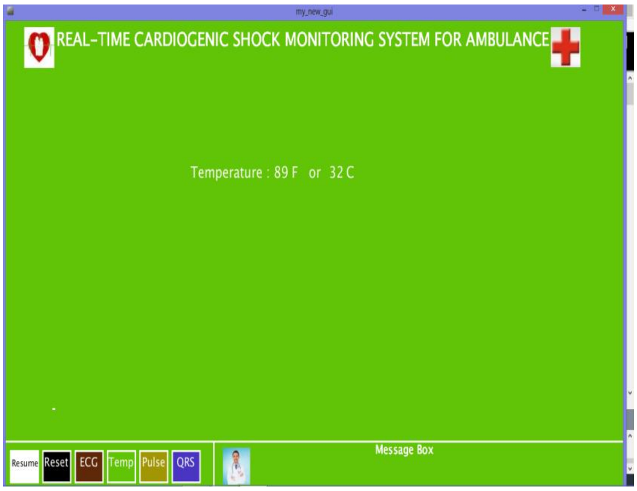

Fig.5 Temperature

Thus the ECG signal obtained in the project is in good match with the actual ECG signal having SNR of 63.52db.

SNR of the signal obtained from the sensors can be calculated using the equation below.

$$SNR = 20 * \log [\text{signal voltage/noise voltage}]$$

SNR values at different stages are shown in Table1.

Stage	Signal Voltage	Noise Voltage	SNR
After Analog Filtering	0.6V	0.04V	23.52dB
After digital filtering and transmission Receiver site	0.6V	0.4mV	63.52dB

Table 1:SNR values

VII. CONCLUSION

The design was successfully dissected into various modules. Each module with the exception of the database system has been implemented. The integration of the individual modules was achieved successfully. The wireless transceiver proved to be an excellent choice. Initial teething problems were experienced during the implementation as the datasheet was not very well documented. Although slightly more challenging to implement than the Nordic options, the RF link is considerably more reliable.. The functionality was based on low cost ECG software used in hospitals in South Africa. The ECG trace however is very temperamental with respect to clarity. At times the trace is up to industry standard ECG machines.

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VIII. FUTURE WORK

Further we plan to incorporate several more signals like ,Pulse, SpO2, EEG into this system to make it into a comprehensive ambulance assist system, particularly in cases of accidents when acute bleeding causes circulatory shock. The degree of circulatory shock revealed by this system helps in preparation at the hospital end to ensure quick emergency treatment.

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