International Journal of Electrical and Electronics Research ISSN 2348-6988 (online)
Vol. 3, Issue 3, pp: (70-77), Month: July - September 2015, Available at: www.researchpublish.com

Design of Remote ECG Monitoring System Based On GPRS

[1]SUPRIYA B. LATE, [2]PROF. DILIP S. BHOSALE

M.E.-E&TC (VLSI & Embedded Systems) 2nd year JSPM's BSIOTR, Pune, Maharashtra, India

Abstract: **A remote ECG monitoring system design method based on GPRS wireless communication is proposed. This method mainly uses LPC2138 controller, combined with SIM 900 GPRS module though AT instructions to devise ECG monitoring instrument. Design and develop remote ECG monitoring software in doctor's workstation, realizing the remote monitoring of ECG signals.**

Keywords: **GPRS, ECG monitoring, LPC 2138**.

I. INTRODUCTION

Study reveal that among all the diseases the three major causes accounting for the increase in mortality rate in India are cardiovascular disease, Cancer and Kidney failure. Where death in India due to Cancer accounts for 19.6% each year and Kidney failure accounts for 16.9%.Cardiovascular disease is one of the main causes of death in India and it accounts for 35% of all death each year. Among patients who had heart attacks, about 60% of them reach hospital well after 60 minutes of the onset of the heart attack. Although heart attack can happen suddenly without apparent indications, cardiac rhythm disturbances can often be found before the event. They can potentially be used as the precursor to major cardiac episodes.

In today' scenario there are different techniques by which signals or data can be transmitted. ECG data can be transferred to the central location or to the mobile phones by compressing and using Bluetooth wireless technology .The ECG signals are captured using dry skin electrodes and then these signals extracted from the electrodes are amplified, filtered using band pass filter and then are transmitted using Bluetooth wireless technology. However with this wireless technology we face the problem of range since the Bluetooth has the range of 10m and hence the motive of continuously monitoring the patient carrying out his daily activity or the patient out of the hospital or homes cannot be accomplished. Hence in order to get rid of this problem GSM/GPRS technology is used.

A. Related Work:

1. R. Sukanesh, S. Palanivel Rajan, S. Vijayprasath, S. Janardhana Prabhu, P. Subathra "GSM-based ECG Tele-alert System", International Journal of Computer Science and Application Issue 2010 ISSN 0974-0767.

According to an estimate, given by the World Health Organization (WHO), cardiovascular disease kills almost seventeen million people around the globe each year along with twenty million people at a risk of sudden heart failure.

As per discussion with renowned cardiologists, there are considerable changes that occur in ECG signals at very initial stage or onset of heart attack. Also, there is a time between onset of heart attack and actual event occurrence and this period generally depends upon the patient's age, habits like smoking, drinking, etc. In the normal cases doctors generally get a period of 60 minutes to control the ECG signals and this period is referred to be as golden hour. So, if it is possible to signal a warning message to the patient and the doctor at the very initial stage of attack, then patient's life can be saved.

2. ECG Wireless Telemetry M.SRINAGESH, P. SARALA, K.DURGA APARNA, International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 8, February 2013 ISSN: 2277-3754 ISO 9001:2008 Certified.

A Holter monitor is a small box that is strapped to a patient's waist or shoulder to monitor the heart for 24 to 48 hours or up to 30 days during a patient's normal daily activity. After the monitoring period, the patient returns to the office for the

monitor to be removed. The ambulatory monitor is usually a small tape recorder or digital disc. When the recording is finished, it is examined with a special instrument called a scanner. The ECG tracing is then analyzed and interpreted by the physician. Since in this case patient at remote location can be monitored but not continuously that is the patient is monitored for 24 hours, data is captured and then that particular monitor (holter) is returned for interpretation.

Telemetry is another way of monitoring remotely located patient. However in this case for small distance transmission channel like coaxial cable, telephonic lines etc are used. Also for long distance communication RF transmission technique is used. But RF communication technique suffers from lot of interference problem.

II. IMPLEMENTATION

A. ECG introduction:

Electrocardiograph (ECG) is a transthoracic interpretation of the electrical activity of the heart over time captured and externally recorded by skin electrodes. It is a noninvasive recording produced by an electrocardiographic device. The ECG works mostly by detecting and amplifying the tiny electrical changes on the skin that are caused when the heart muscle "depolarizes" during each heartbeat. At rest, each heart muscle cell has a charge across its outer wall, or cell membrane reducing this charge towards zero is called de-polarization, which activates the mechanisms in the cell that cause it to contract. During each heartbeat a healthy heart will have an orderly progression of a wave of depolarization that is triggered by the cells in the sinoatrial node, spreads out through the atrium passes through "intrinsic conduction pathways" and then spreads all over the ventricles. This is detected as tiny rises and falls in the voltage between two electrodes placed either side of the heart which is displayed as a wavy line either on a screen or on paper. This display indicates the overall rhythm of the heart and weaknesses in different parts of the heart muscle. The word electrocardiography is evolved from Greek word Kardia which means Heart. ECG that is electrocardiograpy is a process of interpretation of heart activity over the period of time and is detected by electrodes attached to the surface of body (skin). An ECG is used to measure the heart's electrical conduction system. It picks up electrical impulses generated by the polarization and depolarization of cardiac tissue and translates into a waveform. The waveform is then used to measure the rate and regularity of heartbeats, as well as the size and position of the chambers, the presence of any damage to the heart, and the effects of the drugs or devices used to regulate the heart, such as a pacemaker. A typical ECG tracing of a normal heartbeat (or cardiac cycle) consists of a P wave, a QRS complex and a T wave (Figure 1). The baseline voltage of the electrocardiogram is known as the isoelectric line. Typically the isoelectric line is measured as the portion of the tracing following the T wave and preceding the next P wave In medicine, specifically cardiology, the QT interval is a measure of the time between the start of the Q wave and the end of the T wave in the heart's electrical cycle. The QT interval generally represents electrical depolarization and repolarization of the left and right ventricles. The QT interval is dependent on the heart rate in an obvious way. The standard clinical correction is to use Bazett's formula to calculate the heartrate-corrected QT interval QTc.

$$QTc = \frac{QT}{\sqrt{RR}}$$

here QTc is the QT interval corrected for heart rate, and RR is the interval from the onset of one QRS complex to the onset of the next QRS complex, measured in seconds, often derived from the heart rate (HR) as 60/HR (here QT measured in milliseconds).

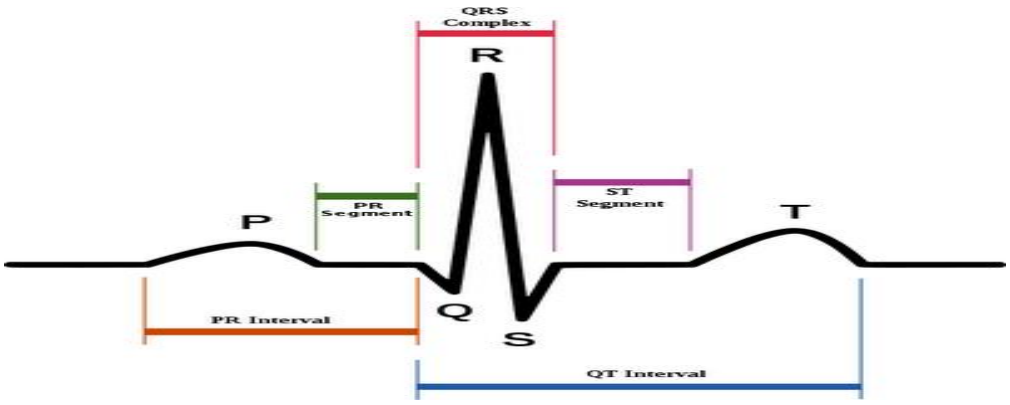

Figure 1. Typical ECG waveform

B. The Overall Design of Remote ECG Monitoring:

The system is composed of three parts, which includes: ECG signal acquisition part, wireless transmission part and doctor's workstation part. The specific implementation adopts the client/server structure form to realize remote ECG signal monitoring system, and in the client/server model it uses modular design concept. The client includes ECG data pickup module, MCU controller module, and wireless data transmission module together to construct the remote ECG monitoring instrument, and the server constitute doctor workstation. The structure form of client /server brings a great convenience to design. The client can be liberated to precede ECG signal extraction and characteristic ECG parameters monitoring, and not a very complex ECG information comprehencive processing. Thus the ECG monitoring instrument can be made small and exquisite, and easy to wear for patients. Because computer's data processing ability is stronger than single chip, the workstation receives ECG data transferred from the remote ECG monitoring instrument, which can carry out complex later stange ECG data processing.

C. Proposed Methodology:

The ECG signal is extracted from the wireless ECG sensor and amplified. This amplified signal is then digitized using ADC as shown in the figure4. Digitized ECG data is then transmitted using GSM/GPRS wireless technology. On the parallel lines at the receiving end the ECG data is received using GSM/GPRS technology and displayed on PC of doctor for analysis.

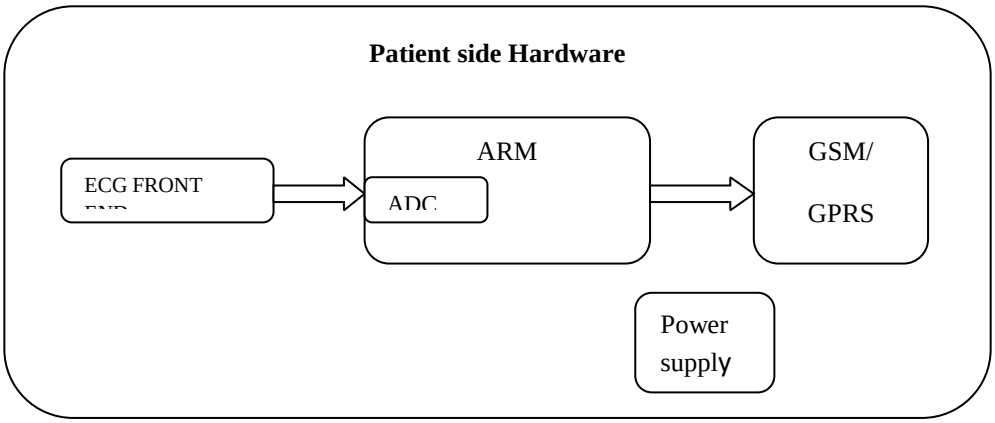

Figure 2. Patient side modules to extract and transmit ECG signal

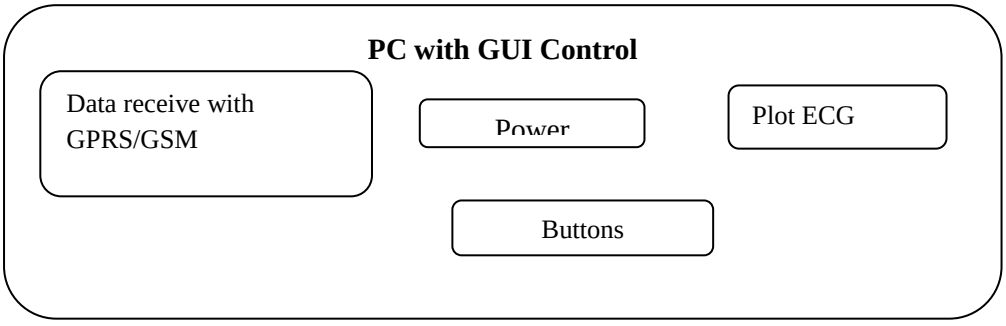

Figure 3. Doctor Side modules for reception and analyzing ECG signal

D. Proposed Basic Transmission Technique:

There are various transmission techniques that can be used to transmit ECG data as said earlier. But the new approach is one in which controller is combined with SIM900 GPRS wireless communication module. Also, since the ECG data is an important data and any loss in that is not tolerable, it is essential to look for the protocol that provide the data integrity. Also, when the data from multiple patients is to be transmitted then care must be taken that there is no data mixing. Thus, it can be said that we need to establish and terminate the connection to the doctor workstation when the data is to be transmitted and received successfully respectively. This can be achieved with TCP/IP protocol which provides you with the feature of data retransmission. Hence, TCP/IP protocol is reliable protocol when data integrity comes into picture.

After the system is power on, SIM300 module starts normally. Firstly, initialization of the module is required. The initialization includes: Set the feedback method of SIM900 module, serial port baud rate, local port number, low power consumption mode, GPRS connection, GPRS data transmission method, text message receiving format, and GPRS data receiving format. Through the feedback information from SIM900 module, judge whether each initialization AT instruction is successful. Once this initialization is successful TCP/IP protocol is used to build the TCP connection with doctor workstation.

Figure below indicates the transmission of ECG data to the doctor workstation.

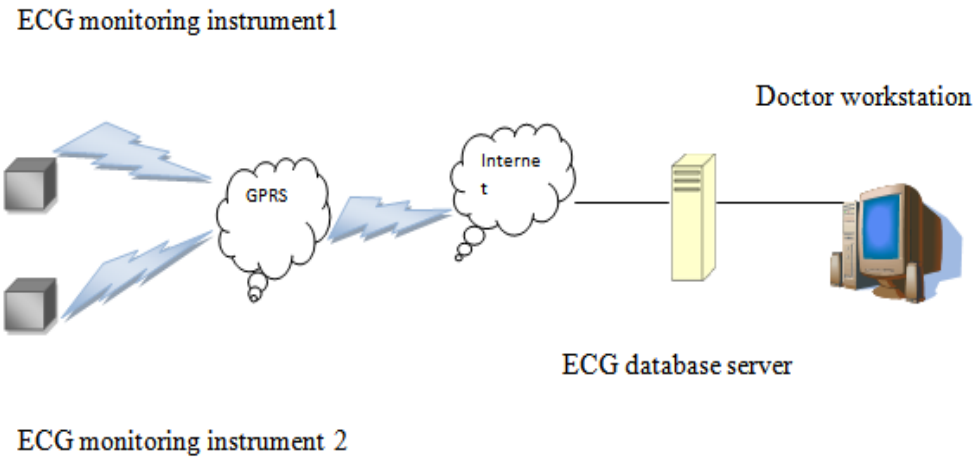

Figure 4. Complete system architecture.

E. Approach Followed To Carry Out Work:

1. Function and Specification of Proposed System:

The following are the functional specifications for the ECG:

- To provide a real time 3-lead ECG trace on a P.C.
- A simple intuitive GUI that may be used by a person with no medical background.
- Transmission of data from remote unit is initiated from sensor node.
- Easy setup and installation of entire system.
- Two separate units. A portable unit that is attached to the person being monitored. A second unit interfaces directly to the P.C and acquires data that is being transmitted wirelessly from first unit.
- The portable device is light weight, compact and unobtrusive.
- Received data can be visualized on PC.

2. Hardware Description:

EXPERIMENTAL SET-UP:

HARDWARE REQUIREMENTS:

- 3 lead ECG.
- ECG Acquisition board consisting of INA212,OPA2335
- DSO
- ARM LPC2138 Kit.
- PC with standard configurations

2.1 THE THREE LEAD ECG:

The electrical activity can be represented as a dipole (a vector between two point charges). The placement of the electrodes on the body determines the view of the vector as a function of time. Figure 5represents the most basic form of the electrode placement which is based on Einthoven's triangle. This theoretical triangle is drawn around the heart with each apex of the triangle representing where the fluids around the heart connect electrically with the limbs. Lead I measures the differential potential between the right and left arms, Lead II between the right arm and left leg, and Lead III between the left arm and left leg.

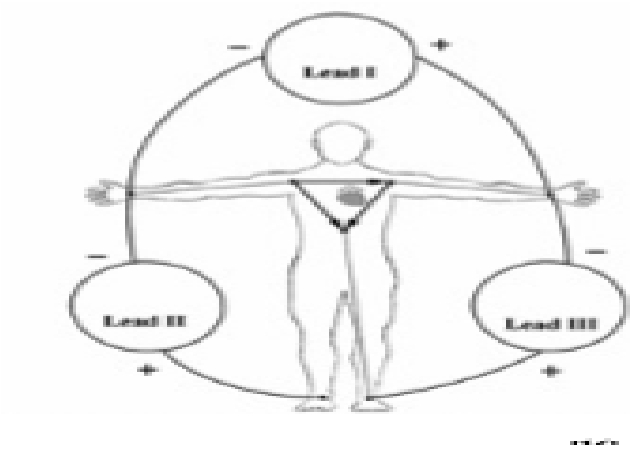

Figure 5. Three lead

Einthoven's law also states that the value of any point of the triangle can be computed as long as values for the other two points are known. This point is crucial in the implementation of the design. It simplifies the overall analogue design and reduces the component count (and most importantly cost) as only two differential amplifiers are required. If any two leads (of the three lead ECG) are generated using the front end hardware the third lead may be generated entirely by software by simply subtracting (or adding) the two leads obtained from the analogue front end. The equations presented below verify the above statement. The Einthoven limb leads (standard leads) are defined in the following way:

Lead I:

Lead I: VI = ϕl - ϕr (1) ϕl = potential at the left arm

Lead II: VII = ϕf - ϕr (2) ϕr = potential at the right arm

Lead III: VIII = ϕf- ϕl (3) ϕf = potential at the left foot

Manipulation of the above results yields: Lead I + Lead III = Lead II.

$$\phi l - \phi r + \phi f - \phi l = \phi f - \phi r$$

Similarly,

Lead II - Lead I = Lead III

Figure 6. 3 lead ECG clamp

2.2 DESIGN FOR REAL TIME ACQUISITION OF ECG DATA:

DESIGN CONSIDERATION FOR AMPLIFIER:

- ECG signals vary from µV to mv range
- For better interpretation these signals must be amplified.
- Biopotential amplifiers high input impedance and are designed for safety first.
- Isolation and protection circuit are used to prevent and limit current through electrodes to a safe level.
- Output impedance of the amplifier should be very low to drive any external loadwith minimal distortion.
- Should have high gain.
- High CMRR to eliminate large offset signal.
- Most biopotential amplifier are differential.
- Differential amplifier are used to ensure that the noise from the inputs are not amplified thus yielding a higher integrity signal

2.3 ECG acquisition and Filter design:

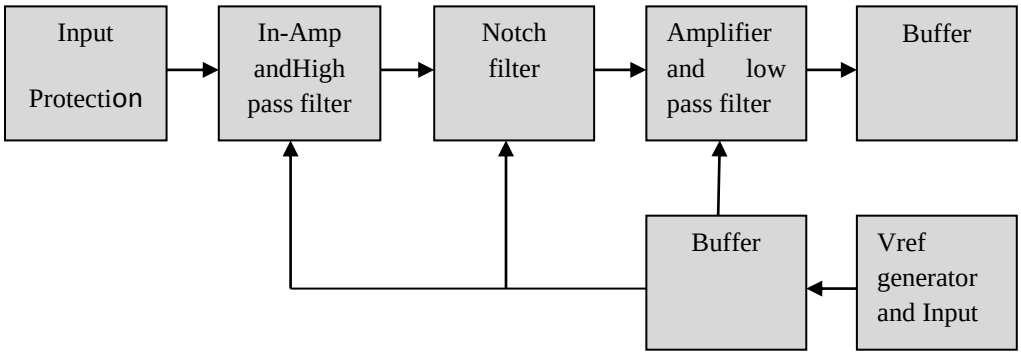

Figure 7. Block diagram of ECG acquisition system

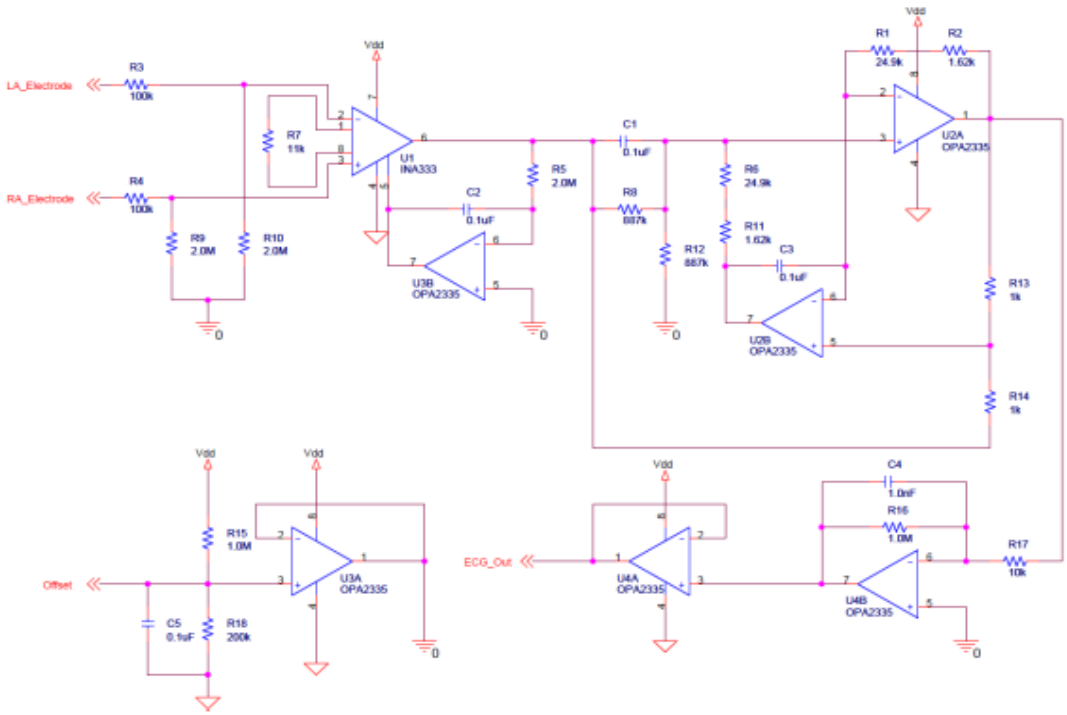

Figure 8. ECG acquisition and Filter design

E. TRANSMISSION TECHNIQUES:

Once the real time ECG signal is captured, the next goal is to transmit that signal to the remote location that is at the doctor workstation efficiently using wireless transmission technique.

When it comes to wireless technology, there are various transmission techniques comprising of analog and digital modulation. Again further techniques are divided into amplitude, Frequency phase modulation and into PCM, CDMA, TDMA, FDMA respectively.

When RFID transmission technique is used for transmission of ECG signal various modulation techniques can be used. However, there are certain severe problems like wireless signal energy loss during propagation, and radio refection / diffraction / scattering that occur in the transmission and may lead to improper interpretation of the data due to loss in it. Also, the signal strength goes on decreasing as the as the distance goes on increasing. This can be represented by the equation as follows

$P_{received} \alpha (distance)^2$

There are several methods to cope up with this problem [18] but again there is no 100% assurance of faithful reception of data.

Bluetooth and other wireless technology making use of FDM, TDM technologies although provide faithful reception range is the main obstacle in using those modules.

Thus, here GSM/GPRS modules play important role. However to have faithful reception of data a reliable protocol must be used. Again there are various protocols say UDP TCP etc.

When using UDP it is clear that one will get good speed at expense of no acknowledgement. But since as in this project we are confined to ECG signal, loss in the ECG data cannot be tolerated since that may give rise to severe consequences.

Hence it is clear that one should use a protocol that provides data integrity. So, here TCP plays an important role. Since TCP protocol provides acknowledgement on every reception of data we can ensure about faithful reception of data. Also, since there connection establishment and connection termination phenomenon, same protocol can be used when dealing with multiple patients with multiple disease. TCP is also provided with feature of time out. That is if the packet is lost and no acknowledgement is received then after a stipulated time the packet is sent again. Also here question arises about bandwidth when dealing with acknowledgement. In that case piggybacking is one of the techniques that can used to efficiently use the available bandwidth. Thus, overall looking at the concept of TCP protocol, TCP is best suited for this research work.

A proposed system enables to extract real time ECG data of remotely located patient efficiently and that data can be transmitted to the doctor workstation using wireless technology. In this work TCP protocol is proposed that ensures the data integrity, because of the characteristic of acknowledgement on data reception. As we are dealing with ECG signal transmission it is mandatory that there should not be any loss in the ECG data and that the data should be transmitted continuously. And all these requirements can be achieved by TCP protocol very efficiently.

However, although data transmission can be achieved using wireless technology, cons of the same should be considered. Wireless transmission may result in distorted signal due to high interference of noisy signals in environment. Sources of interference may be as follows,

The core of the presented approach can be divided into two parts:

1. Acquisition of real time ECG data: Although there are various websites where you get ECG samples that can be digitized and transmitted, we are in the need of real time ECG signal. Hence it is necessary to design an ECG acquisition system. This system is essentially amplifier unit consisting of instrumentation and operational amplifier with right leg drive.

2. Transmission from patient end and reception of the ECG signal at doctor workstation: Once the ECG data is extracted, for wireless transmission it is to be first digitized and then can be sent to wireless module for further transmission to the doctor workstation. On the other hand at the receiving end the received signal is first converted into analog and then is displayed for analyzing.

III. CONCLUSION

Transmission of real time ECG signal is obviously going to save life of human being provided that the signals are analyzed properly. Noise is an important parameter that should considered while working with ECG signals. In this Powerline noise is the one that can be minimized to greater extent by designing proper hardware. But Baseline is the noise that again needs software treatment to get complete pure ECG signal. Also since we are going to transmit ECG signal wirelessly one should make note of wireless transmission loss. This system will be used for real time monitoring of different parameters of health like ECG and temperature of remotely located patient and can be used to provide on spot medical help when required. Due to this system real time ECG signals can be transmitted to the doctor workstation due to which the patient or a person can be signaled a warning message insisting to have treatment as early as possible and ultimately life of person can be saved. TCP/IP protocol provides reliable service in terms of data integrity that is important in case of transmission of ECG signal since any loss in this signal cannot be tolerated. Thus, efficient and secured data transmission can be achieved. This system will allow one to carry out daily activity instead of being in hospital all the time. Also this eliminates the need of routine checkup. This system will enrich or increase the ease of life.

REFERENCES

[1] Cardiovascular diseases in India Challenges and way ahead an International heart protection summit September 2011. India-Heart capital a paper by Mission Hospital Durgapur.

[2] PANIDIS IP and MORGANROTH J., Sudden death in hospitalized patients: cardiac rhythm disturbances detected by ambulatory electrocardiographic monitoring, J Am Coll Cardiol. Nov; 2(5):798-805.

[3] Bo Yu, Liuqing Yang, Chia-chin chong "ECG Monitoring over Bluetooth: Data Compression and Transmission" IEEE conference on Wireless communication and networking ISSN: 1525-3511 (978-1-4244-6396-1) April 2010.

[4] Liang Kai, Xu Zhang, Yuan Wang, Huang Suibiao, Guan Ning, "A system of portable ECG monitoring based on Bluetooth mobile phone" IEEE international Symposium on IT in medicine and education" Dec 2011.

[5] R. Sukanesh, S. Palanivel Rajan, S. Vijayprasath, S. Janardhana Prabhu, P. Subathra "GSM-based ECG Tele-alert System", International Journal of Computer Science and Application Issue 2010 ISSN 0974-0767.