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Applications of GSM Module in Wireless ECG Signal Monitoring System

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Abstract: In this paper, 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. 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 drugs or devices used to regulate the heart, such as a pacemaker. The fully system will be basically for a high cardiac diseased person and if they are moving or they are living alone this system will be very helpful to them.

INTRODUCTION

The monitoring of vital physiological signals has proven to be one of the most efficient ways for continuous and remote tracking of the health status of patients. Electrocardiogram monitors are often used in many medical service centers and hospitals to diagnose and monitor a person's health status by measuring their cardiac activity. An ECG is a noninvasive monitor, which can be utilized to evaluate the heart electrical activity, measure the rate and regularity of heartbeats, the position of the chambers, identify any damage to the heart and investigate the effect of drugs and devices used to regulate the heart.

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 provide a means to continuously monitor several physiological parameters using just one device, a variety of multi-parameter monitors (or biomonitor) systems have been introduced in the past few years, with many of them currently used by hospitals, researchers, and NASA. Although, these devices are commonly used to detect, process and record several physiological signals simultaneously, the conventional telemetry system they employ limits the freedom of movement of the subjects whose biopotentials are being measured. First of all, most of these systems receive power from an electrical outlet and are heavy enough to require wheeling to be displaced; making casual movements or urgent transportation of patients from one location to another very difficult [24], thus resulting in patients being mostly confined to their beds while in a hospital. Moreover, besides limiting the freedom of mobility of the subjects, the wires (used to connect electrodes and the recorder) often constitute a source of noise to the acquisition system. 4And, although such stationary conditions might be acceptable in the case of a bed-ridden patient, it cannot be used for astronauts who are required to constantly move by their activities during space flights. The alternative commercially available biomonitoring devices which can be used under severe non-stationary conditions such as athletic scientific studies are very limited and prove to be costly. These devices are also usually uncomfortable due to their heavy weight, vigorous structure and network of lead cables running from subject to monitor.

LITERATURE REVIEW

Abdelaziz proposed their capacitively coupled ECG measurement system which is more sensitive to moving artifacts. This is useful for heart rate detection in long term applications. The drawback of the system is that an adequate distance between the surface of the electrodes and subject's body is necessary for a high quality ECG measurement. Eurique Mario Spinelli proposed their transconductance driven right leg circuit to reduce common mode interference. They implement a system which provides an extended bandwidth for high frequency EMI rejection and easy to compensate for stability. They also achieved a comparative analysis between a typical driven leg circuit and the proposed system.

Real time ECG data can be transferred to the central location or to the mobile phones by compressing and using Bluetooth wireless technology [6]. Real time patient monitoring system using android smart phones is developed that it can be used to analyze the data and send alert messages to the patient if necessary. Liang Kai, Xu Zhang, Guan Ning, proposed a system where 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.

Real time monitoring of remotely located patient is possible using wireless Zigbee technology. Also when continuously monitoring a patient, streaming is one of the issue and is handled by using Linux OS. With the use efficient wireless technology it is possible to transmit different data like temperature, pulse rate, ECG signal of different patients and also give warning signal with the help of GSM modem. Thus, multiple patients can be monitored with aid of technology. However with this technique range is the main concern since Zigbee is having 100m range. Also, another patient monitoring system was developed in which the remotely located patients are monitored continuously and meaningful data like heart beat, air flow etc. are sent to the smart phones using GSM technology.

Zuan Kang medical grade WLAN architecture for remote ECG monitoring employs the point coordination function (PCF) for medium access control and reed Solomon coding for error control. The basis of their proposal is to split the MAC layer into MAC and LLC layers. The new MAC layer uses the IEEE 802.11PCF mode to achieve deterministic packet delivery, and the LLC layer uses RS-based error control with block interleaving to achieve high reliability.

Data for simulation are from the MIT-BIH database. It shows how the proposed architecture can improve wireless network performance to the extent necessary to support a telecardiology application.

Yong Yen presents a convenient method of ECG measurement for long-term, everyday monitoring without direct conductive contact with the skin while subjects sat on a chair wearing normal clothes. Electrodes with high-input impedance amplifiers mounted on it are used for measurement and have an indirect- contact grounding. The providers face a limitation of lower signal quality than those of conventional methods and the results depend on clothing properties.

As health care centers have becomes popular, daily monitoring of health-status related parameters is becoming important. An easy, comfortable and patient friendly solution for acquisition, processing and remotely transmitting the information from patient to the center is therefore an important issue. Phonocardiogram (PCG) is a physiological signal reflecting the cardiovascular status. The module has three main blocks: Data Acquisition, Signal Processing & Remote Monitoring of heart sounds. Data acquired includes the heart sounds. The system integrates embedded internet technology and wireless technology. As the data is being send by internet, it realizes real-time recording and monitoring of physiological parameter of patients at low cost and both at home and in hospital. The analysis can be carried out using computer initially and further by doctor. The tele-monitoring system may provide a low-cost, reliable and convenient solution for data acquisition and real time analysis of the PCG. The heart sounds are acquired using an acoustic stethoscope and then processed using software developed using the simulation tool.

A Monitoring system capable of reading an ECG signal and temperature signal of a patient and is then transmitted via Bluetooth to a display module that can be a personal computer (PC) or a telephony device remote is presented mobile. The captured information is sent via a GPRS network to a database implemented on a server for storage and later reference if necessary and visualization. A Web application allows access to data from any Internet-connected device. There are several errors in the capture of the ECG signal, as technical artifacts, and thus cause erroneous interpretations misdiagnosis. Mechanical or electrical artifacts caused by poor contact or movement can be simulated person arrhythmias similarly excessive movement can cause false readings as outdated appearances ST segment. The problem of correct acquisition of different biomedical signals deserves special attention since this depends the success of the processes such as visualization, interpretation and remote diagnosis.

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GSM MODULE IN ECG SYSTEMS

The proposed ECG Tele-Alert system is shown in fig.1.Our model consists of an ECG bio amplifier that picks up the bio signal and then converts into electrical signal followed by a low pass filter. Output is digitized by an A/D converter, and then programmed in AT89C52 Micro controller followed by the GSM MODEM. The patient (client) and the health-care professional can be located anywhere in the globe where there is 2G cellular network coverage. The primary purpose is to monitor patient's cardiac activity if there is a chance that patient has cardiac problems such as an irregular heartbeat or arrhythmia that require close monitoring .

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.

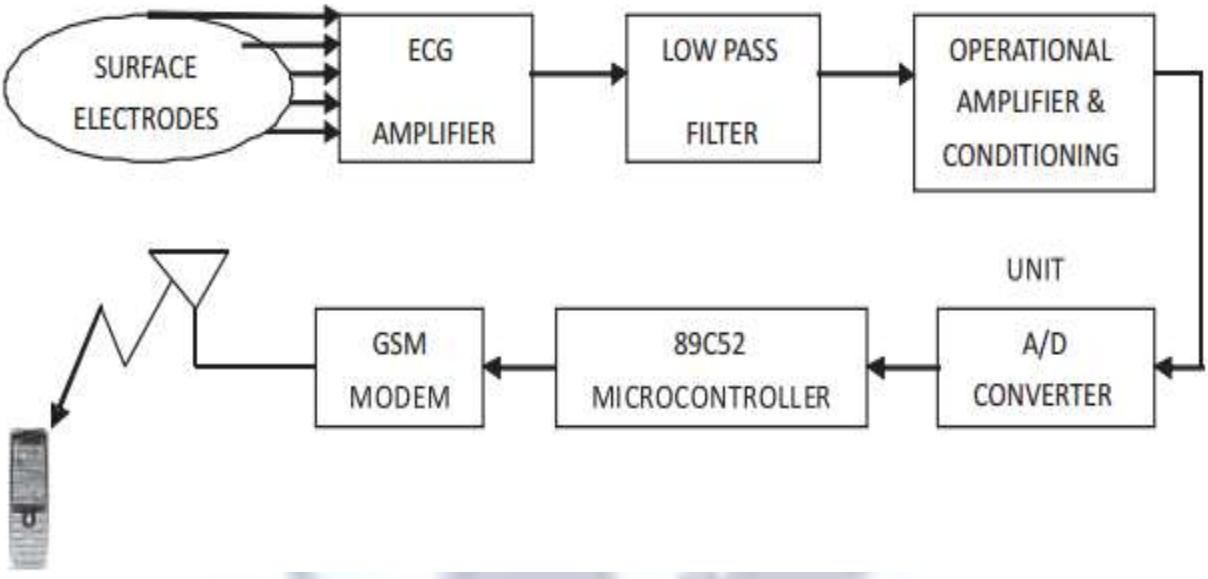

Fig. 1: GSM based ECG System

Mobile Phone Based Intelligent monitoring Platform: 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. 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 ECG Monitoring System and Transmission Using MMS: 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.

The implementation of the Zigbee & GSM based system has also been described using below block diagram:

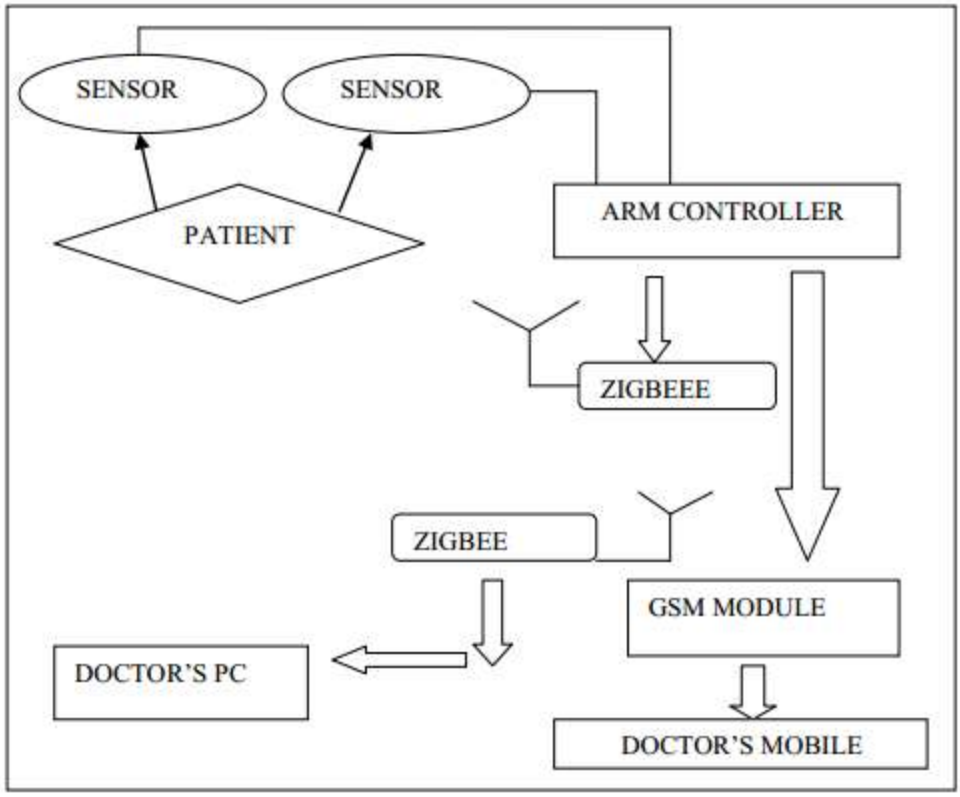

Figure 2: Zigbee & GSM based monitoring system

Applications of Wireless ECG Transmitter System

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.

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.

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.

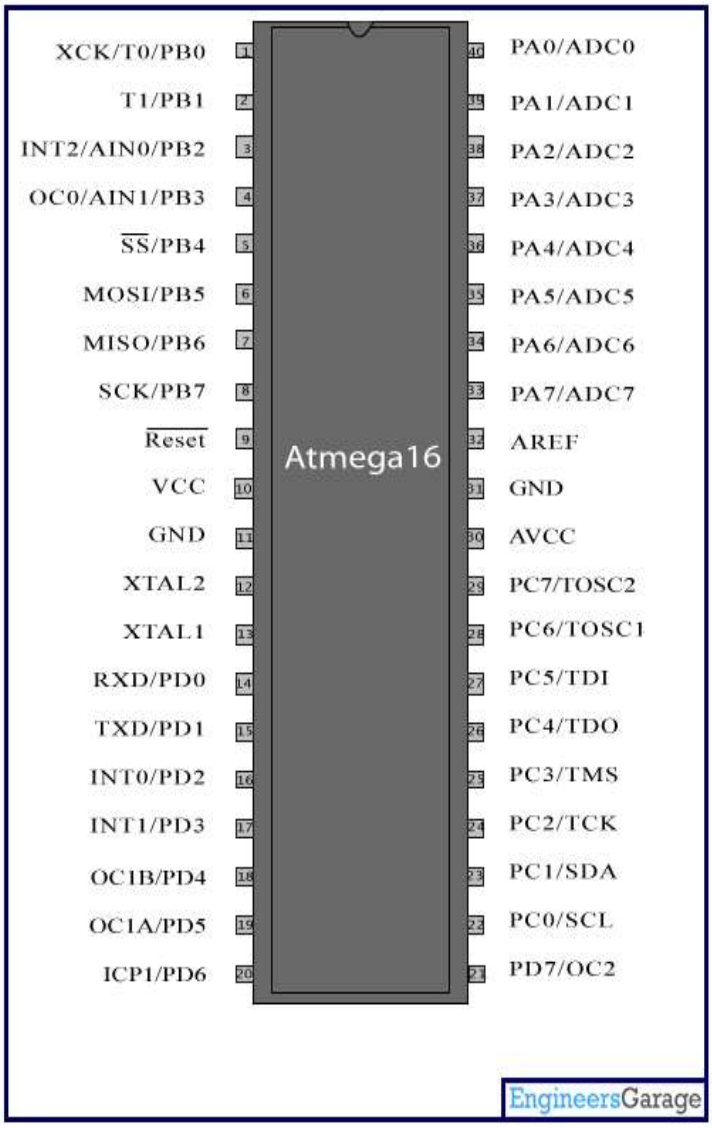

Fig. 3: Pin Diagram of Microcontroller

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.

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

F. 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.

CONCLUSION

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.

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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