ISSN 0974-0767

GSM-based ECG Tele-alert System

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Abstract- **Cardiac arrest is quoted as the major contributor to sudden and unexpected death rate in the modern stress filled lifestyle around the globe. A system that warns the person about the onset of the disease earlier automatically will be a boon to the society. This is achievable by deploying advances in wireless technology to the existing patient monitoring system. This paper proposes the development of a module that provides mobility to the doctor and the patient, by adopting a simple and popular technique, detecting the abnormalities in the bio signal of the patient in advance and sending an alert sms to the doctor through Global system for Mobile(GSM) thereby taking suitable precautionary measures thus reducing the critical level of the patient**

Index Terms- ***Electrocardiogram (ECG) Diagnosis, GSM, Wireless transmission***

I. INTRODUCTION

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. Some of these lives can often be saved if acute care and cardiac surgery is provided within the so-called golden hour. So the need for advice on first hand medical attention and promotion of good health by patient monitoring and follow-up becomes inevitable. Hence, patients who are at risk require that their cardiac health to be monitored frequently whether they are indoors or outdoors so that emergency treatment is possible. Telemedicine is widely considered to be part of the inevitable future of the modern practice of medicine.

It is gaining more and more momentum as a new approach for patients' surveillance outside of hospitals (at home) to encourage public safety, a ciliate early diagnosis, treatment, and for increased convenience. Defined as the "use of advanced Tele Communication technologies " to exchange the information about the patient's health care status and provide health care services across is now currently being used by doctors, hospitals and other healthcare providers around the world with conventional mode of treatment. Telemedicine systems are already available to enable the doctor to monitor a patient remotely for home care emergency applications. Nowadays, Wireless networking is an emerging technology that will allow different users to accesselectronically, regardless of their geographic topography. The use of wireless communication between mobile users has become increasingly popular due to the advancements in computer and wireless technologies. Implementation of wireless technology in the existing ECG monitoring system eliminates the physical constraints imposed by hard-wired link and allows users to conduct own check up at anytime anywhere.

The usage of mobile phone has been recognized as a possible tool for telemedicine since it has become a commercially available household article. In the recent past, it has been shown that a bio signal acquisition unit connected to a computer, vital signs can be transmitted from an ambulance to a hospital in a store-and-forward mode or in real-time mode. Moreover, newer cellular access technologies, such as Third generation (3G), and others provide much higher data transmission speeds (rates) than basic second generation (2G) GSM cellular system offering future telemedicine solutions endless choices for high-end designs. These relatively new wireless technologies are deployed mostly in or around crowded high income metropolitan areas for our proposed scheme.

But the majority (80.8%) of the 3.7 billion cellular phone users in the world are still 2G GSM users. Hence, we describe a telemedicine system based on mobile messaging service namely: Short Messaging Service (SMS), which is an integral part of the original 2G GSM cellular system and subsequent generations since all new phones are SMS capable. Our project aims at detecting the cardiac disorder of the patient in advance thereby reducing the critical level of the patient by following precautionary measures at an earlier instant.

II. SYSTEM CONCEPT

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 .

ISSN 0974-0767

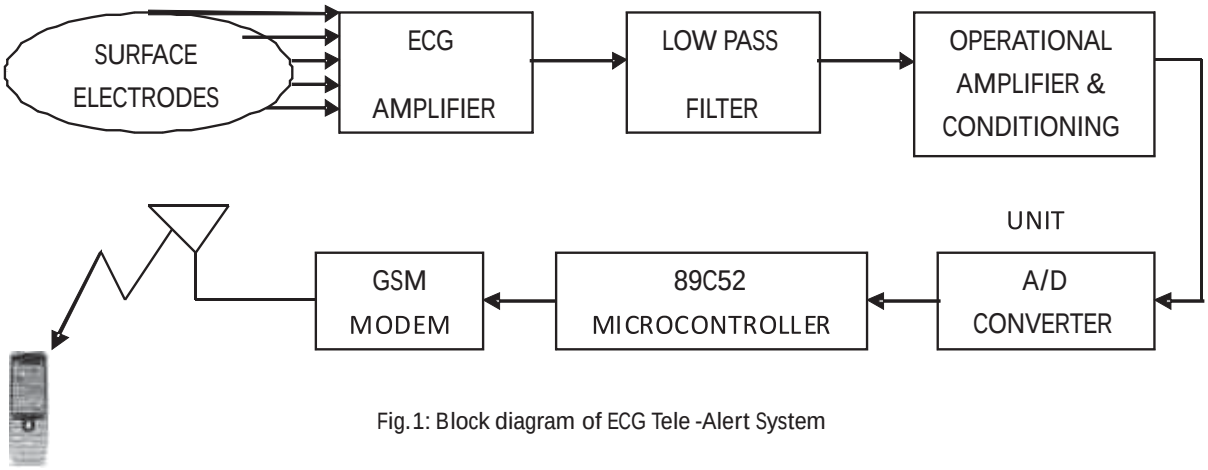

Fig.1: Block diagram of ECG Tele -Alert System

The ECG is a graphical representation of electrical activities of the heart with respect to time. ECG also refers to the painless and non-invasive method that records the Electrocardiogram signal. Normal electrocardiogram with its characteristic patterns and significant points and intervals is shown in Fig.2.

Fig.2: Graphical Representation of ECG signal

The amplitude of a QRS- complex is typically about ±1-2mV.When the patient's cardiac level goes beyond the threshold, our system alerts the patient by sending an alert SMS to the doctor's mobile through the GSM MODEM. This proposed model is an enhanced version of the current patient monitoring system where we are providing mobility to both the doctor and patient.

III. PATIENT UNIT

The patient unit is comprised of the ECG signal acquisition module that comprises of the ECG electrodes which are used for picking up the bio-electric potentials caused by heart muscle followed by an ECG amplifier. The presence of noise gives rise to the need for signal filtering by a low pass filter and signal conditioning unit.

A. ECG Leads

The first stage is a transducer AgCl electrode, which convert bio signal (ECG) into electrical voltage. The voltage is in the range of 1 mV to 5 mV. We feed the signals from the five electrodes (Right arm, left arm, right leg, left leg and the chest) into the inputs of the designed instrumentation amplifier conditioning circuit of an overall gain of 1000. The signal is band pass filtered with a well frequency range from 0.15-50 Hz. The ECG derived from the surface bears here frequency components up to a maximum frequency of 100Hz, but most of the spectrum is concentrated below 40 Hz.

B.ECG Amplifier

The front-end for the signal acquisition system is an instrumentation amplifier. It has a very high common mode rejection ratio (CMRR) and high input impedance which is required for capturing ECG signals.

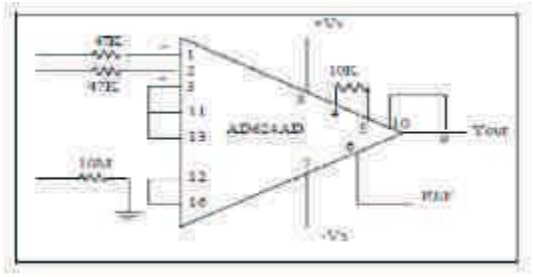

Fig.3: Circuit diagram of ECG Amplifier

The AD624 instrumentation amplifier is a high-Precision, low-noise, instrumentation amplifier designed primarily for use with bio-electronics. The pin connections of the AD624 are shown in fig.3. A gain of 1000 was setup by connecting pins 3, 11 and 13.

C. *Low Pass Filter*

The second stage was a low-pass filter designed at the cut-off frequency of 100Hz. The low Pass filter was implemented as cascaded RC, or passive filters. At high frequencies, the op-amp, whose output is limited to its slew rate or maximum frequency of output, may not be able to cope with the high frequency of the signal. For this reason, the low pass filter was implemented as cascaded RC filters before isolating the filter from the rest of the circuit by a voltage follower.

The cut-off frequency was calculated by the equation,

$$f_c = 1 / 2\pi RC \qquad (1)$$

At the cut-off frequency of the first filter, the attenuation is

ISSN 0974-0767

determined as 20dB/decade ($f_c \times 10$). At the cut-off frequency of the second filter, the attenuation is set at 40dB/decade thereafter. Typically, if the two cut-off frequencies are equal,

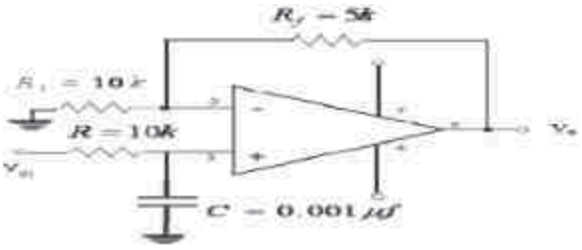

Fig.4: Circuit diagram of Low Pass Filter

then the slope is 40dB/decade from the common cut-off frequency. Second stage impedance must be higher than the first. Fig.4 shows the circuit diagram of the low pass filter used in the system. It is non-inverting and has a gain of unity.

D. Signal Conditioning Unit

The next task is amplification of ECG signals before digitizing, commonly discussed as signal conditioning, which includes analog signal filtering, demodulation, sampling and holding, etc. Amplification of signals before digitizing is done with the aim to get the highest resolution and to maximize effective number of bits for the Analog to Digital Conversion.

Overall gain is calculated using the equation given below

$$A=1+R_F/R_1 \qquad (2)$$

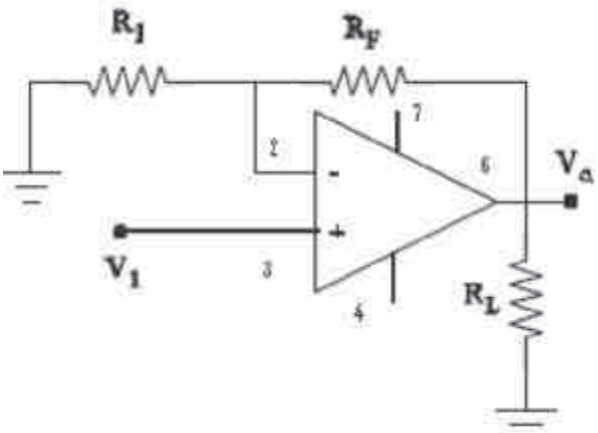

Fig.5: Amplification circuit

IV. ANALOG TO DIGITAL CONVERTER

Analogue devices ADuC831 data acquisition system was used to manage the digitization of the EKG signal and subsequently store it for the transmission. The ADuC831 (shown in Fig.6) has a built-in 12-bit ADC which was used for digitization. The ADC has 8 channels and is configurable via 3- registers (ADCCON1, ADCCON2 ADCCON3) with Special Function Register (SFR) interface. The analog input voltage range is from 0V to V_{REF}. The supply voltage, V_{REF}, is set to 9V in the system. Once configured through ADCCON1-3 SFRs, the ADC converts the analog input and provides a 12-bit result.

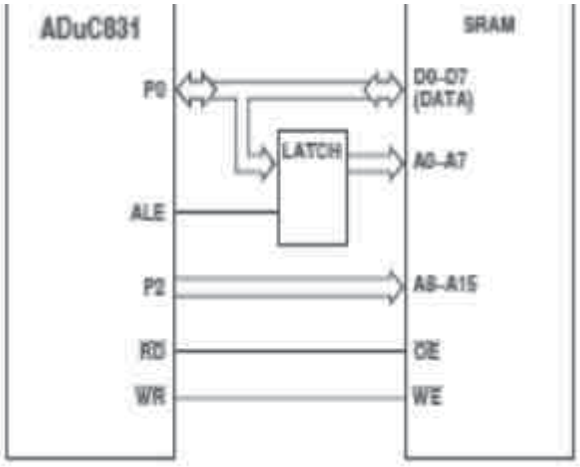

Fig.6: Interfacing ADC with serial Devices

signal as input to slow processing circuits like ADCs to match with its conversion time.A successive approximation ADC is a type of analog-to-digital converter that converts a continuous analog waveform into a discrete digital representation. Successive approximation works by constantly comparing the input voltage to the output of an internal digital to analog converter (DAC, fed by the current value of the approximation) until the best approximation is achieved. At each step in this process, a binary value of the approximation is stored in a successive approximation register (SAR).

V. 89C52 MICRO CONTROLLER

The AT89C52 is a low power, high performance CMOS 8-bit Microcomputer with 4K bytes of Flash programmable and erasable read only memory (PEROM).

Fig.7: Pin details of AT89C52

ISSN 0974-0767

The device is manufactured using a ATMEL'S very high-density nonvolatile memory technology and is compatible with the industry-standard MCS-52 instruction set and pin out. The on-chip flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer.

By combining a versatile 8 bit CPU with Flash on a monolithic chip, the ATMEL 89C52 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications. Pin details of the AT89C52 Micro controller is given in Fig.7. The heart of our project is microcontroller section in which we are using on-chip Flash memory array set.

The 89C52 flash reliably stores memory contents even after 10,000 erase and program cycles. The cell is designed to optimize the erase and programming mechanisms. In addition, the combination of advanced tunnel oxide processing and low internal electric fields for erase and programming operations produces reliable cycling.

VI. GSM MODEM

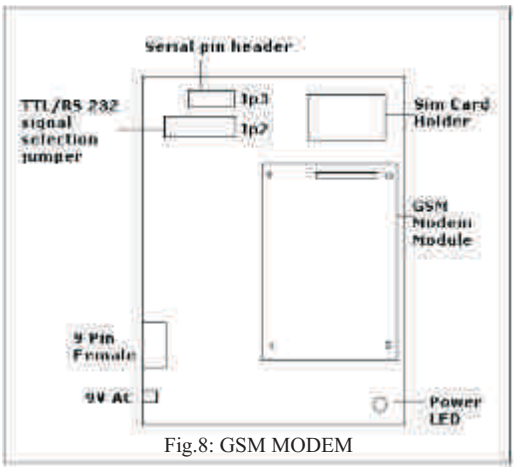

Fig.8: GSM MODEM

The GSM MODEM supports popular "Attention (AT)" command set so that users can develop applications quickly. This product provides great feasibility for devices in remote location to stay connected which otherwise would not have been possible where telephone lines do not exist.Whenever the safe range of the PQRST wave of the patient is violated, the programmed microcontroller interfaced with GSM MODEM sends an alert sms to the doctor's mobile number specified, deploying wireless technology.

VII. RESULTS

A. Electrodes Placement

As a general principle the closer, the electrodes are to the heart, the stronger the ECG signal that will be obtained. In our Lead V formation, electrodes were placed on the right arm, left arm, right leg, left leg and chest with right leg electrode acting as the ground reference electrode for the body.

B. Simulation results

Simulations were performed using LabVIEW. The LabVIEW design and observed output is shown in Fig.9 and Fig.10.

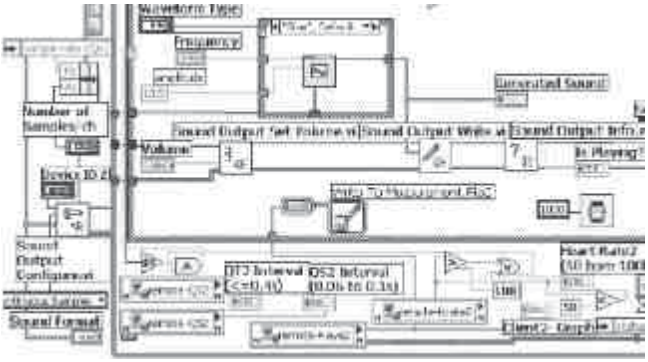

Fig.9: LabVIEW block design

Fig.10: Observed results

VIII. CONCLUSION AND FUTURE WORK

The major value of this Tele-alert system is in the detection of cardiac disorder (Heart attack) of the patients who are located in the remote areas or in travel and are not in a position to report to the doctor for immediate treatment. An alert SMS can be transmitted using the GSM technology to the doctors and advises can be sought for saving the life of the patient. So far we have developed a model for enhancing the mobility of doctor alone and in future we will extend the prototype by providing mobility to both doctor and patient.

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