A GSM ENABLED REAL TIME SIMULATED HEART RATE MONITORING & CONTROL SYSTEM

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Abstract

Aged people or physically handicapped people and the people suffering from some serious diseases are usually confined to their homes, due to their health conditions. They are put into a helpless situation when they need to go out for even small tasks like walking, shopping, meeting friends and relatives. Their movement is restricted to such an extent that they may start to feel isolated from the society and develop boredom and depression.

This paper deals with the design and development of GSM enabled Heart Rate Monitoring & Control system. The system uses GSM for communicating the abnormalities in heat rate values. Abnormal deviation in the values of any of these parameters from their set point values will be immediately sensed and local help is sought from the nearby people. If no such help is available, this system sends SMS directly to home, doctor or care taker's mobile phone. Heart rate is the number of heat-beats per unit of time, typically expressed as beats per minute (bpm). An attempt is made to design and develop a system that uses a simulator circuit to crate abnormalities in the heart rate which includes Tachycardia and Bradycardia conditions. It is a bi-directional communication system in which the care taker/Doctor, also can send SMS to know the present parameter status of the person or patient.

Keywords: *Heart Rate Simulator circuit, Dual Band GSM Modem, bradycardia and tachycardia*

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1. INTRODUCTION

Embedded systems are widely used in monitoring & control of various physical parameters [1-3]. Automated monitoring and controlling of various parameters through the use of short distance wireless communication methods are in use [4-6]. However such systems restrict the distance between transmitting & remote terminal. It is always preferred to use wireless telemetry systems for biomedical applications as these biological signals can be well observed in living conditions. Another version of very short distance communication method adopted by researchers is the Bluetooth technology [7,8]. The GSM (Global System for Mobile Communication) which offers worldwide communication and GPS (Global Position System) which also offers ability to localize an object anywhere on the earth The researchers have suggested the use of this GSM & GPS technology for monitoring the biomedical parameters of patient from remote terminal [9, 10, 11]. The application of GSM/GPS communication methods does not restrict to any specific parameters, even automobile tracking purpose are also in use [12,13]. But the wireless telemetry system for biomedical application involves monitoring of various parameters like blood pressure (NIBP), body temperature etc. The old age people/patient requires continuous monitoring of their health conditions even when they go out of their home.

The aim of the proposed work is to study the abnormalities in biomedical parameters (heart rate) and to inform it to a caretaker using GSM communication network. This paper deals with design of a simulated heart rate monitoring & control system based on GSM network. The design of hardware and software for a compact, reliable and low cost system to achieve remote monitoring is studied. In this system, monitoring of simulated biomedical parameters is implemented for simulated heart rate. Creation of abnormalities in the heart rate on living beings is quite difficult. Hence, it is proposed for simulated heart rate by using simulator circuit. In the event of any abnormalities, it gives messages on LCD display and sounds the buzzer to alert the people around and to seek help from them. In case no help is available within the stipulated time, then the system sends SMS message to the concerned Doctor or care taker

2. HARDWARE OF THE PROPOSED SYSTEM

Here we have proposed a GSM enabled simulated biomedical parameter (heart rate) monitoring & controlling system. The system has two parts, one is the system unit and the other is

mobile unit (cell phone). It makes use of GSM network & its facility for mobile communication to transmit the status of physiological parameters of the person to an authorized person's cell phone. In the proposed system, both system unit & mobile unit (a cell phone) can act as transmitter & receiver, as it is a bi-directional communication system. The system unit, which has a microcontroller, collects the data & compares for any abnormal deviations from their set values. In case of deviations; it sends an SMS to the care giver's cell phone along with values of biomedical parameters.

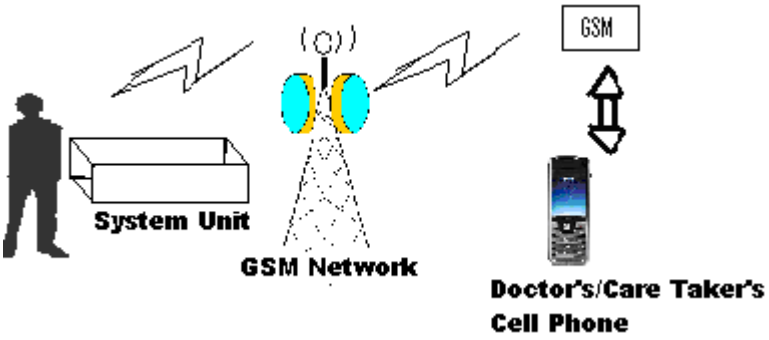

Fig-1: The system outline

The system responds to SMS messages sent by the doctor or the other caregiver, verifies the authenticity and then sends a reply SMS. By the response SMS sent by this system, the doctor or the caretaker can know the heat rate of the person or patient. Fig.1 shows the system block diagram.

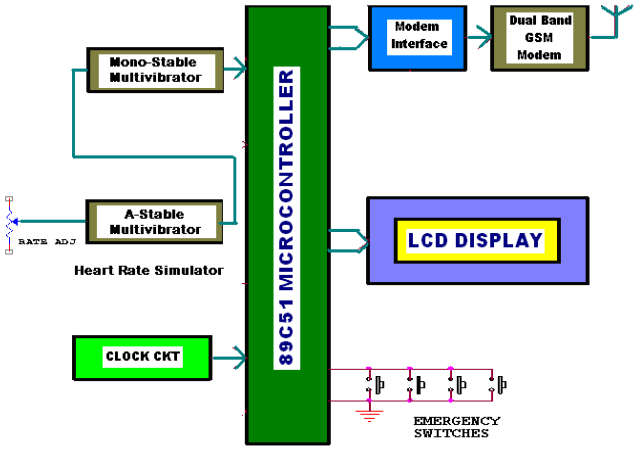

Fig-2: Block diagram of System Unit

The block diagram of this proposed system includes all the general components of a standard embedded system like Microcontroller, Simulator circuit, Dual band GSM Modem & LCD unit etc. The details of few hardware components are;
Embedded Microcontroller
Heart Rate Simulator circuit
Dual Band GSM Modem
Modem interface unit
LCD Display unit
Emergency Switches
Power Supply

2.1 Embedded Microcontroller

The microcontroller chosen for this work is Atmel's 89C52 and it does all controlling activities of the system by executing a program stored into its flash program memory. It is an 8-bit microcontroller with 8-k bytes of internal flash program memory, 256-byte data memory and 4-I/O ports. It also consists of a full duplex serial UART and internal timer/counter. It is an ideal choice for compact embedded system design for such applications.

2.2 Heart Rate Simulator Circuit

Heart rate is the number of heartbeats per unit of time, typically expressed as beats per minute (bpm). Heart rate can vary as the body's need to absorb oxygen and excrete carbon dioxide during physical exercise, sleep, illness, or as a result of ingesting drugs etc in which the heart rate speeds up or slows down. Most involve stimulant-like endorphins and hormones being released in the brain, many of which are those that are 'forced'/'enticed' out by the ingestion and processing of drugs.

Heart rate is measured by finding the pulse of the heart. This pulse rate can be found at any point on the body where the artery's pulsation is transmitted to the surface by pressuring it with the index and middle fingers; often it is compressed against an underlying structure like bone. The thumb should not be used for measuring another person's heart rate, as its strong pulse may interfere with the correct perception of the target pulse.

Abnormalities

1). Tachycardia is a resting heart rate more than 100 beats per minute. This number can vary as younger ones and children have faster heart rates than average adults.
2). Bradycardia is defined as a heart rate less than 60 beats per minute although it is seldom symptomatic until below 50 bpm when a human is at total rest. This number can vary as children and younger ones tend to have faster heart rates than average adults. Bradycardia may be associated with medical conditions such as hypothyroidism.

In order to demonstrate all functionalities of this system, conditions have to be created to have normal and abnormal parameter. Since, in order to evaluate this instrument creating all the possible normal and abnormal conditions on a living human subject (person) is not possible. Hence, we have provided an additional arrangement to artificially produce brady-cardia and techy-cardia conditions. This system actually

simulates the patient's cardiac conditions. Thus it enables us to calibrate and test the performance of the instrument rigorously under various conditions of the heart rate. This heart rate simulator circuit uses one a-stable multi-vibrator and one mono-stable multi-vibrator. The a-stable multi-vibrator produces continuous train of pluses at adjustable frequency and the mono-stable multi-vibrator shapes these pulses into a pulse of fixed width that is suitable to be read by the microcontroller. The microcontroller evaluates present heart rate, by measuring the duration between two consecutive pulses. Once the heart rate becomes abnormal, it displays message on LCD display and buzzer to alert the people around to seek help from them.

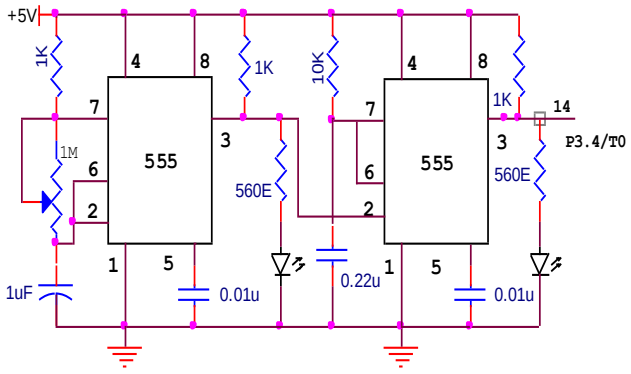

Fig-3: Circuit diagram of the simulator

As Shown in the circuit diagram, there is a heart rate simulator which uses two 555 IC timers. One of them is used in astabale mode and the other in mono-stable mode. The pulses are generated in an astable multivibrator. Varying the 1Mohm potentiometer, connected between the pin number 2 and 7 can vary the frequency of this circuit. The output of astable multi vibrator is taken from the pin number 3 and is given to pin no 2 of monostable multivibrator. The output of the astable multivibrator acts as a trigger input for monostable multivibrator. The output of monostable multivibrator produces pulses depending upon the trigger input, but with a constant pulse width, as determined by the R-C values.

The internal timer (implemented through software), of micro-controller continuously checks for these pulses and reads the heart rate. The pulse from mono-stable multi vibrator determines the heart rate, by measuring the time between two successive pulses. Thus it obtains the present heart rate and compares each of heart rate reading value with maximum and minimum limit stored in microcontroller's memory. If the values are within limits, it continuous the process of checking heart rate. Once the heart rate becomes abnormal at any instant, it produces a loud sound message by activating the speech processor and also displays the message on LCD to alert the doctor or other medical staff.

2.3 Dual Band GSM Modem:

It is a wireless MODEM and can send and receive data through the GSM network. It requires a SIM card and connectivity to the GSM network. It consists of built in TCP/IP stack. The GSM MODEM communicates with the embedded microcontroller system with the help of AT commands. It works on two frequencies i.e. 900 MHz and 1800 MHz for up-linking and down-linking. Hence it is referred to as Dual band GSM MODEM. This MODEM is designed to work on RS232 standard, hence, while connecting to microcontroller, a RS232 to TTL level converter is required.

2.4 LCD Display Unit

This system has a LCD module for displaying various messages according to the situation. Position, parameters and the code received. A 2-line, 16 character type LCD module with backlit facility is used. The microcontroller sends the signals to LCD module through its ports.

2.5 Emergency Switches

These are simple push button switches. In the event of any abnormalities, if the patient or person presses any emergency switch, buzzer is used alert the people around and to seek help from them.

2.6 Power Supply Unit

Since this instrument has to be carried by the patient while moving. Hence it is essential that the entire patient's unit has to be designed to work on batteries. It consists of rechargeable batteries, filter capacitors and voltage regulators. The batteries can be charged by a regular charger.

2.7 Subscriber Identity Module

One of the key features of GSM is the Subscriber Identity Module (SIM), commonly known as a SIM card. The SIM is a detachable smart card containing the user's subscription information and phonebook.

2.8 Short Message Service (SMS)

Short Message Service (SMS) is popular among mobile phone users as a cheap and convenient method of communicating. Since the use of SMS technology is a cheap, convenient and flexible way of conveying data. One of such areas that the SMS technology could be used for remote monitoring and controlling

3. SOFTWARE IMPLEMENTATION

Since this system is designed as a dedicated embedded system, software has been developed without the use of any generalized operating system. Hence, the system program is written in Assembly language as it produces the most compact

hex code. The system comes to ON condition from RESET position when power is applied. The microcontroller executes program from 0000H memory location and performs the following tasks in the sequential order.

- Microcontrollers Port configurations initialization.
- Initialization of Serial Port, setting its baud rate and enabling the Interrupt system.
- LCD display initialization and setting its parameters.
- Display of initial title message on LCD.
- Obtains Heart rate and displays on LCD display.
- Compares present values with their internal SET values.
- If any of readings of values are abnormal, it displays a message on LCD and turns on the buzzer and waits for DISABLE button to be pressed within a stipulated time.
- If DISABLE button is pressed within stipulated time, it disables alarm and goes back to monitor patient's parameters again.
- Sending of SMS to the cell phone with GSM modem through AT commands.
- Disabling of alarm and going back to monitor patient's parameters again.

4. EXPERIMENTAL RESULTS & DISCUSSION

The problem faces by the elderly people/patient as quoted earlier is tried to solve in the proposed system. This system has to demonstrate its functional feasibility with GSM connectivity for simulated biomedical parameter monitoring and intimation of medical emergencies. It was intended to allow the biomedical parameters of a person to be automatically measured from anywhere, without the limitation of distance and make use of GSM mobile technology for communication and thus to extend the range of biomedical parameters to unlimited range.

The patient himself can ask for the help by pressing a button or a micro-switch attached to the instrument whenever he is uncomfortable. If there is nobody to help the person, the microcontroller prepares a concise SMS and sends the information through the GSM modem to the mobile phone of the doctor/care giver of the affected person. Hence helps such people to get the critical help in time. Thus it can assist the aged people. And also serves as a life saving instrument for critically ill patients.

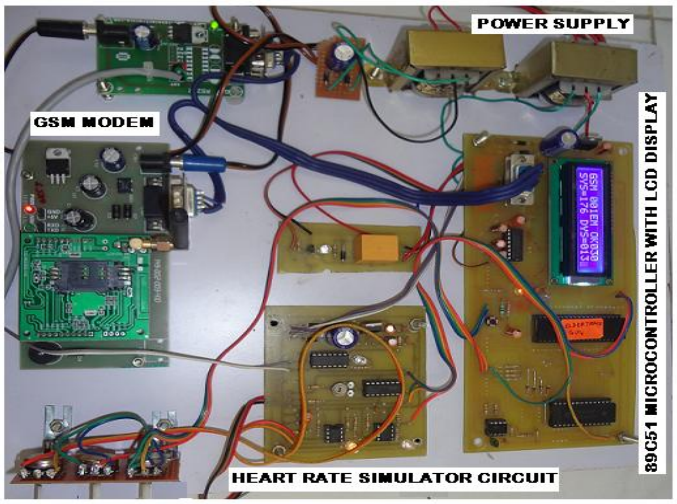

Fig-4: Photograph of the experimental setup

From the above discussions it is clear that the system is automatic, wireless, portable and does the communication of the simulated biomedical parameters of the person to the care giver's/doctor's cell phone.

Fig-5: Photograph of a Mobile phone with SMS sent by the designed system

The details of this SMS are as follows: HR=107 (Heart Rate) abnormal conditions

5. CONCLUSIONS

The objective of this work is to design & implement a low cost GSM enabled wearable simulated biomedical parameter (Heart Rate) monitoring system using Atmel's 89C51 microcontroller. The system is designed, developed and rigorously tested successfully in the laboratory. The developed system is simple, low cost and potable. This system has functional reliably and can be used for studying the creation of abnormalities in the heart rate as otherwise it is very difficult to create the abnormalities on the living subject (human).

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