International Journal of Engineering Research and General Science Volume 3, Issue 4, July-August, 2015
ISSN 2091-2730

HEARTBEAT MONITORING AND ALERT SYSTEM USING GSM TECHNOLOGY

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ABSTRACT: Health related issues and parameters are of utmost importance to man, and is essential to his existence and influence and thus he has sought for an improved system that would be able to capture and monitor the changes in health parameters irrespective of time and location so as to provide for measures that will forestall abnormalities and cater for emergencies. This work presents a system that is capable of providing real time remote monitoring of the heartbeat with improvements of an alarm and SMS alert. This project aims at the design and implementation of a low cost but efficient and flexible heartbeat monitoring and alert system using GSM technology. It is designed in such a way that the heartbeat/pulse rate is sensed and measured by the sensors which sends the signals to the control unit for proper processing and determination of the heartbeat rate which is displayed on an LCD, it then proceeds to alert by an alarm and SMS sent to the mobile phone of the medical expert or health personnel, if and only if the threshold value of the heartbeat rate is maximally exceeded. Thus this system proposes a continuous, real time, remote, safe and accurate monitoring of the heartbeat rate and helps in patient's diagnosis and early and preventive treatment of cardiovascular ailments.

Keywords: Parameters, Sensors, Emergencies, GSM Technology, SMS, Real time monitoring, Heartbeat rate,

INTRODUCTION

Cardiovascular disease is one of the main causes of death in many countries and thus it accounts for the over 15 million deaths worldwide. In addition, several million people are disabled by cardiovascular disease [1]. The delay between the first symptom of any cardiac ailment and the call for medical assistance has a large variation among different patients and can have fatal consequences. One critical inference drawn from epidemiological data is that deployment of resources for early detection and treatment of heart disease has a higher potential of reducing fatality associated with cardiac disease than improved care after hospitalization. Hence new strategies are needed in order to reduce time before treatment. Monitoring of patients is one possible solution. Also, the trend towards an independent lifestyle has also increased the demand for personalized non-hospital based care. Cardiovascular disease has shown that heart beat rate plays a key role in the risk of heart attack. Heart disease such as heart attack, coronary heart disease, congestive heart failure, and congenital heart disease is the leading cause of death for men and women in many countries. Most of the time, heart disease problems harm the elderly person. Very frequently, they live with their own and no one is willing to monitor them for 24 hours a day [1].

In this proposed device, the heart beat and temperature of patients are measured by using sensors as analog data, later it is converted into digital data using analog to digital converter (ADC) which is suitable for wireless transmission using SMS messages through GSM modem. Micro controller device is used for temporary storage of the data used for transmission [2]. For a patient who is already diagnosed with fatal heart disease, their heart rate condition has to be monitored continuously. This project proposes and focuses on the design of the heartbeat monitor that is able to monitor the heart beat rate condition of patient continuously. This signal is processed using the microcontroller to determine the heart beat rate per minute. Then, it sends short message service (SMS) alert to the mobile phone of medical experts or patient's family members, or their relativesabout the condition of the patient and abnormal details via SMS. Thus, doctors can monitor and diagnose the patient's condition continuously and could suggest earlier precaution for the patients themselves. This will also alert the family members to quickly attend to the patient.The remote heartbeat monitor proposed in

this work can be used in hospitals and also for patients who can be under continuous monitoring while traveling from place to place,since the system is continuously monitoring the patient.

1. BACKGROUND STUDY

Recent breakthroughs in science and technological innovations have led to an unprecedented advancement in provisions of technological solutions for the numerous problems facing mankind. Researchers are busy leveraging on modern technology to provide better and improved solutions commensurate to the ever increasing demands. A heart rate monitor is a personal monitoring device that allows one to measure one's heart rate in real time or record the heart rate for later study. Early models consisted of a monitoring box with a set of electrode leads which attached to the chest. The first wireless electrocardiogram (ECG) heart rate monitor was invented in 1977 as a training aid for the Finnish National Cross Country Ski team and as 'intensity training' became a popular concept in athletic circles in the mid-80s, retail sales of wireless personal heart monitors started from 1983 [3]. In old versions of the monitor, when a heartbeat is detected a radio signal is transmitted, which the receiver uses to determine the current heart rate. This signal can be a simple radio pulse or a unique coded signal from the chest strap (such as Bluetooth or other low-power radio link); the latter prevents one user's receiver from using signals from other nearby transmitters (known as cross-talk interference) [3]. Newer versions of the heart rate monitor include a microprocessor which is continuously monitoring the ECG and calculating the heart rate, and other parameters. Modern heart rate monitors usually comprise two elements: a chest strap transmitter and a wrist receiver or mobile phone (which usually doubles as a watch or phone). In early plastic straps, water or liquid was required to get good performance. Later units have used conductive smart fabric with built-in microprocessors which analyses the ECG signal to determine heart rate. More advanced models will offer measurements of heart rate variability, activity, and breathing rate to assess parameters relating to a subject's fitness. Sensor fusion algorithms allow these monitors to detect core temperature and dehydration [3]. The digital heartbeat monitor and alert systems provides a more unique, effective and efficient means of real-time monitoring of a patient’s health parameters and has ever since witnessed an unprecedented tremendous advancement as researchers keep searching for better ways to make these monitoring and alert systems more flexible, portable, and efficient. This section presents a review of current research findings and works done so far by different researchers with the same mindset of providing flexible, portable, and efficient monitoring and alert systems.

A Review of Related Works

In the work “Heartbeat monitoring alert via SMS” [4], the heart beat rate is detected using photoplethysmograph (PPG) technique. This signal is processed using PIC16F87 microcontroller to determine the heart beat rate per minute. Then, it sends SMS alert to the mobile phone of medical experts or patient's family members, or their relatives via SMS. Thus, doctors can monitor and diagnose the patient's condition continuously and could suggest earlier precaution for the patients themselves. This will also alert the family members to quickly attend the patient. PPG is a simple and low-cost optical technique that can be used to detect blood volume changes in the micro vascular bed of tissue. Frequently, it is used non-invasively to make measurements at the skin surface. A PPG is often obtained by using a pulse oximeter which illuminates the skin and measures changes in light absorption. Typically, a PPG tools uses an emitter-receiver pair to determine blood flow. It consists of a matched infrared emitter and photodiode, which transmits changes in infrared reflectance resulting from varying blood flow. A heartbeat sensor circuit which adopted PPG technique is designed using MPLAB software.

As a means of making monitoring systems cost effective and flexible, the work “A Low Cost Optical Sensor Based Heart Rate Monitoring System” [5], was conceived by researchers. This proposes the design and implementation of a single Microcontroller based heart rate measuring device that integrates most of the key features of the aforementioned devices and models. The device is compact in size, energy efficient, portable, capable of data storage and well suited for communicating with an external remote device via Bluetooth and cellular communication in case of a medical emergency or routine. It is based on a single Microcontroller chip that utilizes change in amount of reflection of light sensed by a photo transistor. A photo transistor is used to sense the reflected light. Signal received by the photo transistor is very weak and perturbed by high frequency noise. In order for this signal to be processed in Microcontroller, it is needed to eliminate undesired noise. Furthermore, the signal level is to be raised to a satisfactory level so that the spikes coming from the transistor during each time the heart beats can be distinguished properly by the Microcontroller. After noise being properly attenuated, the signal is fed to the Microcontroller where the data processing is done by converting the analog signal to digital signal. This device has been developed with significant operational conformity with its commercial counterparts. It is designed to respond during medical emergencies via Bluetooth and cellular communication. Furthermore, it can store bulk of data and can also be made conveniently portable.

In the work titled "Microcontroller Based Heart Beat Monitoring and Alerting System" [6]. Itexplains how a single-chip microcontroller can be used to analyze heart beat rate in real-time. In addition, it allows doctors to get the heart beat and location of the patient by GSM every twenty four hours. It can also be used to control patients or athletic person over a long period. The system reads stores and analyses the heartbeat repetitively in real-time. The hardware and software design are oriented towards a single-chip microcontroller-based system, hence minimizing the size. The hardware design is based on an embedded system implementation using the PIC16F877 (a 40 bit) microcontroller from microchip.This system consist of Microcontroller (PIC16F877A), heart beat sensor, GSM modem, GPS receiver. For measuring Heartbeat, input is taken from the finger. Heart beat sensor will generate digital pulse corresponding to each beat. This pulse is counted by interfacing heart beat sensor to microcontroller to pin no. 15(TICKL) and programming the microcontroller in counter mode. After counting of pulse for one minute, value of heart beat will be displayed on LCD and if value is beyond the normal range then location of patient will be messaged to doctor or health attendant personnel using GSM.

B Proposed System

This works presents a lot of considerations and improvements that were incorporated in to the functionality of the device so as to reflect desired features such as cost, design complexity, size, software development, weight, lack of portability etc. This design uses a miniaturized pulse sensor (IC sensor) which has been optimized for very accurate sensing and measurement of changes in the heartbeat rate. The system calculates the heartbeat rate in beat per minute (BPM) with the help of the microcontroller, displays the measured heart rate on a 16X2 character LCD and sends an SMS with current BPM value, each time the heart rate goes above or below a fixed threshold, while at the same time setting off a buzzer alarm attached to the patient module to trigger an alert. With small size and portability in mind, the choice of the LCD display and miniaturized sensor aims at eliminating the need for a PC display, while making it easier to carry the system about, for continuous monitoring. It thus ensures flexibility in real-time remote monitoring regardless of distance and location.Another interesting feature of this particular design is the reprogrammable and open source nature of the product, which makes it easier to re-specify the particular heart rate to watch out for, as well as play with the system parameters, to suit the users need better. This is necessary due to varying environmental and patient conditions. The introduction of the open source Arduino board in this project makes it exceptionally unique and thus opens door for greater exploration and maximization of its great flexibility features and the extent to which it can be implemented for a variety of functions.

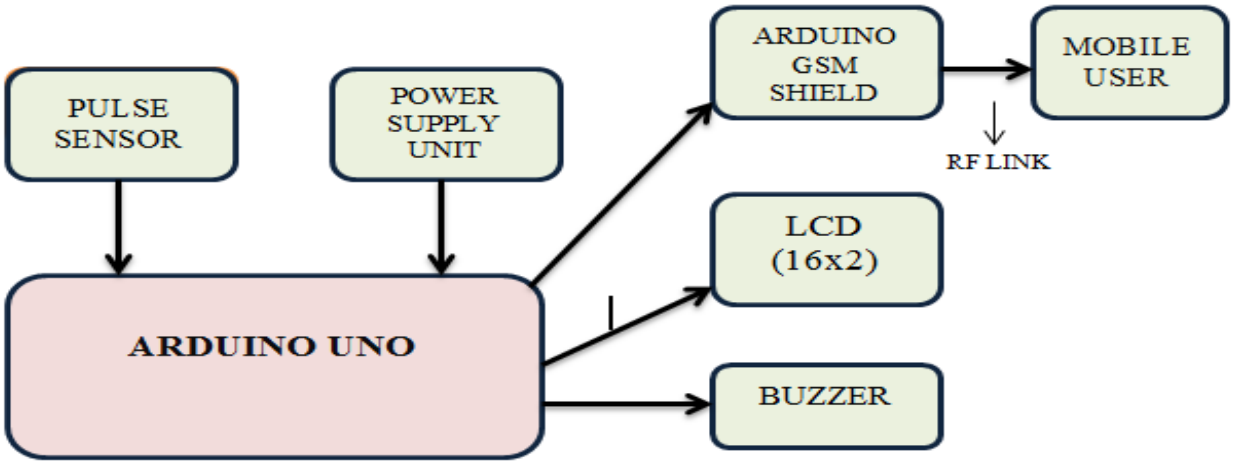

FIG 1 The Block diagram of The Heartbeat Monitoring and Alert System

2. FUNCTIONAL UNITS OF THE SYSTEM

A Power Supply Unit

This unit was developed around, built and incorporated in the arduinouno board. The power supply source for the system would be mains AC. The circuit would use a 12v DC and consists of the rectifier diode, smoothening capacitor and the voltage regulator.

B The Arduino Uno Board

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.

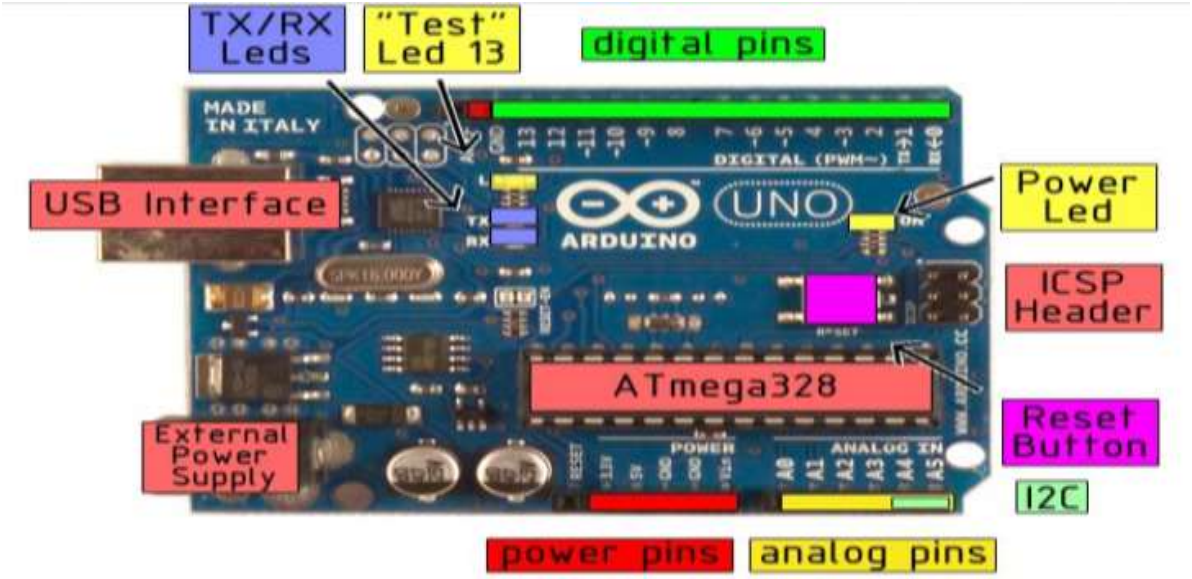

FIG 2 Block diagram of the Arduino Board

C The Arduino GSM Shield/Module

The Arduino GSM Shield allows an Arduino board to connect to the internet, make/receive voice calls and send/receive SMS messages. The shield uses a radio modem M10 by Quectel (datasheet). It is possible to communicate with the board using AT commands. The GSM library has a large number of methods for communication with the shield. The shield uses digital pins 2 and 3 for software serial communication with the M10. The M10 is a Quad-band GSM/GPRS modem that works at frequencies GSM850MHz, GSM900MHz, DCS1800MHz and PCS1900MHz. It supports TCP/UDP and HTTP protocols through a GPRS connection.As always with Arduino, every element of the platform – hardware, software and documentation is freely available and open-source. A GSM module assembles a GSM modem with standard communication interfaces like RS-232 (Serial Port), USB etc., so that it can be easily interfaced with a computer or a microprocessor / microcontroller based system. The power supply circuit is also built into the module and can be activated using a suitable adaptor. Like a GSM mobile phone, a GSM modem requires a SIM card from a wireless carrier in order to operate. The GSM/GPRS module is designed to enable communication between the microcontroller and GMS network. The GSM/GPRS MODEM can perform the following operations:

1. Receive, send or delete SMS messages in a SIM.
2. Read, add, search phonebook entries of the SIM.
3. Make, Receive, or reject a voice call.

It is recommended that the board be powered with an external power supply that can provide between 700mA and 1000mA. Powering an Arduino and the GSM shield from a USB connection is not recommended, as USB cannot provide the required current for when the modem is in heavy use. The modem can pull up to 2A of current at peak usage, which can occur during data transmission.

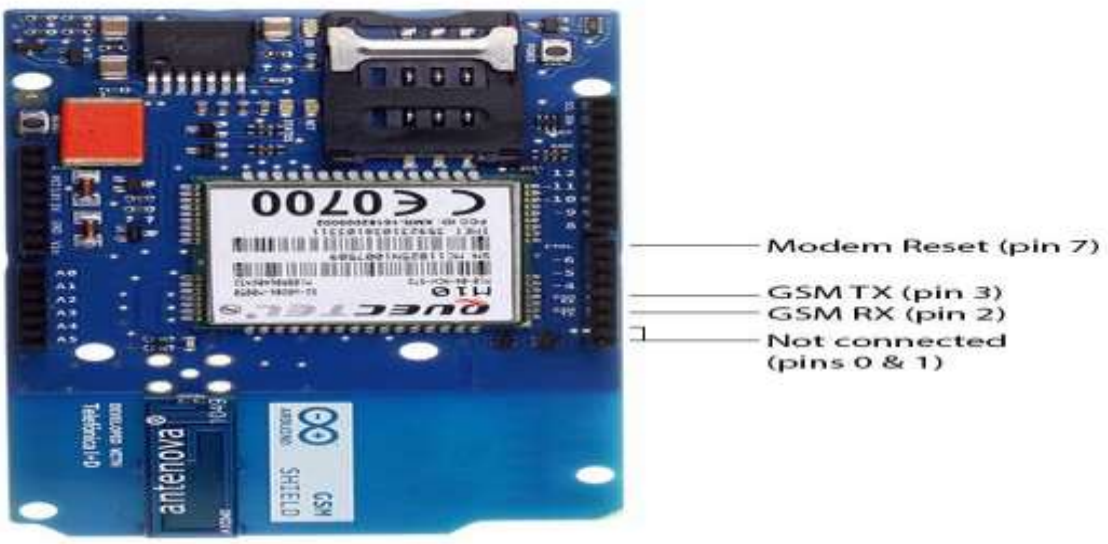

FIG 3 Pin Outs of TheArduinoGsm Shield

D The Pulse Sensor Unit

A Heartbeat sensor is a monitoring device that allows one to measure his or her heart rate in real time or record the heart rate for later study. It provides a simple way to study the heart function. This sensor monitors the flow of blood through the finger and is designed to give digital output of the heartbeat when a finger is placed on it. When the sensor is working, the beat LED flashes in unison with each heartbeat. This digital output can be connected to the microcontroller directly to measure the Beats per Minute (BPM) rate. It works on the principle of light modulation by blood flow through finger at each pulse [7]. The Pulse Sensor is a well-designed plug-and-play heart-rate sensor for Arduino. It also includes an open-source monitoring app that graphs your pulse in real time.

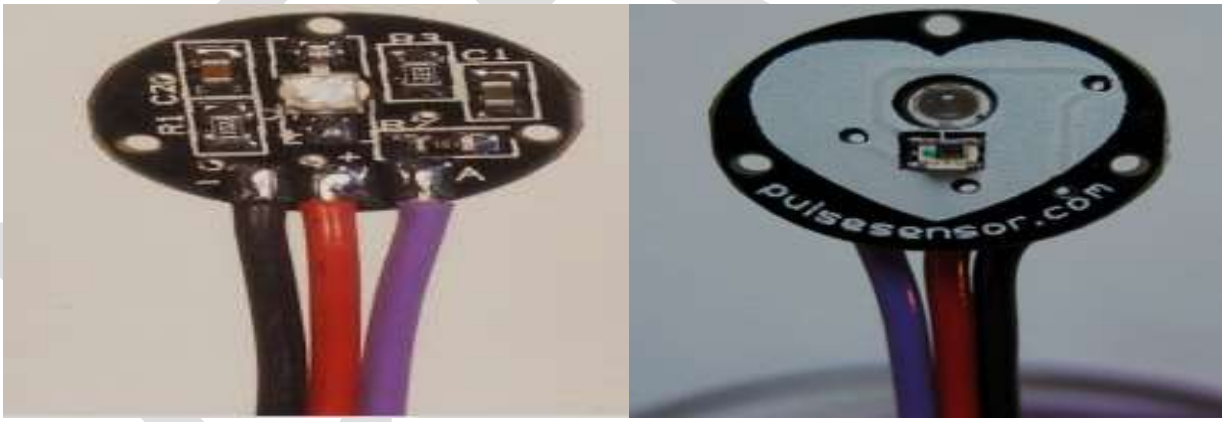

FIG 4 The Pulse Sensor

The Pulse Sensor can be connected to arduino with jumpers. The Code for Hardware and Software otherwise known asThe Processing code is called ‘P_PulseSensor_xx’ ,running this code on this data visualization software gives:

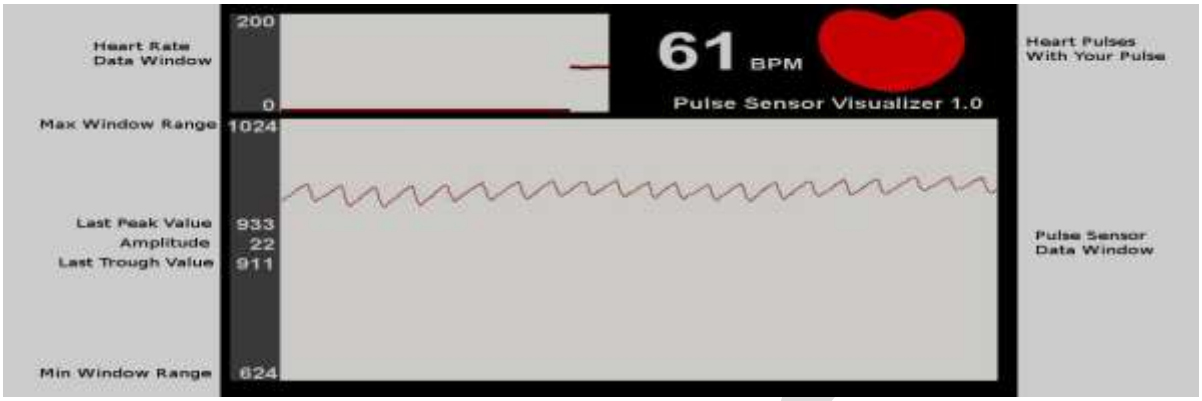

FIG 5 Pulse Sensor Output Graph

The group of three numbers on the left correspond to the pulse waveform peak, trough, and amplitude. At the top of the screen, a smaller data window graphs heart rate over time. This graph advances every pulse, and the Beats Per Minute is updated every 10 heart pulses. The big red heart also pulses to the time of your heartbeat. When you hold the Pulse Sensor to your fingertip, you should see a nice saw-tooth waveform like the one above. The pulse sensor amped is a greatly improved version of the original pulse sensor. This version incorporates amplification and noise cancellation circuitry into the hardware, making it much more reliable. It is compatible with 3.3 and 5v microcontrollers giving you more flexibility and the processing visualization software and arduino code have been streamlined and improved.Arduino watches the analog signal from pulse sensor, and a pulse is found when the signal rises above the mid-point, that's the moment when the capillary tissue gets slammed with a surge of fresh blood. When the signal drops below the mid-point, arduino sees this and gets ready to find the next pulse. The digital pulses are given to the microcontroller for calculating the heat beat rate, given by the formula- BPM (Beats per minute) = 60*fWhere f is the pulse frequency. We have built in hysteresis to the rising and falling thresholds which can be adjusted if necessary [8].

E LCD Display Unit

Liquid Crystal Display (LCD) modules that display characters such as text and numbers are the most cheapest and simplest to use of all LCDs. They can be purchased in various Sizes, which are measured by the number of rows and columns of characters they can display. Any LCD with an HD44780- or KS0066-compatible interface is compatible with Arduino. A 16x2 LCD display is very basic electronic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs because they are economical, easily programmable, has no limitation of displaying special and even custom characters (unlike in seven segments), animations and so on . A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD [9].

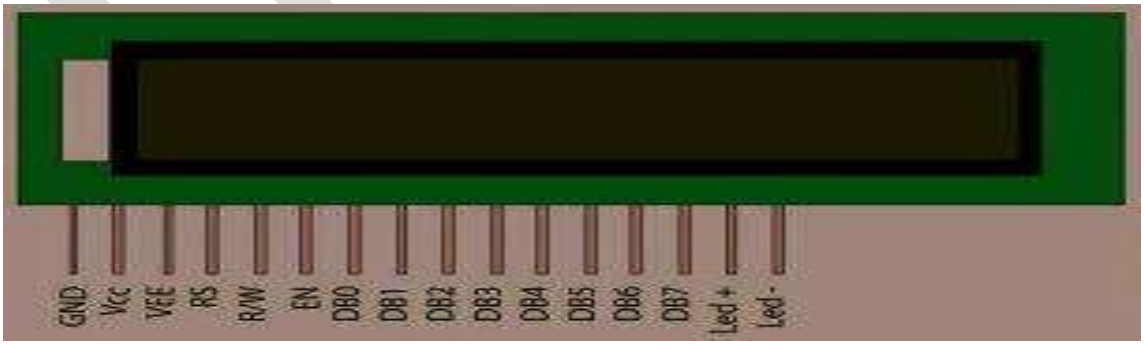

FIG 6 Pin Out ofThe LCD

F Buzzer

A **buzzer** or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric and finds extensive use in electronics circuits and designs especially to trigger an alarm or as a system alert device. The buzzer is simply powered with a regulated 5v.

FIG 7 Buzzer

G Mobile User

The mobile user is simply any GSM mobile phone that is able to send and receive an SMS. The microcontroller issues control signal which instructs the GSM Module to send an SMS remotely over the GSM network to the GSM Mobile phone which receives the message sent to it. The GSM Module and the program algorithm can also be designed that the SMS message sent is to multiple pre-defined mobile users.

3. SYSTEM EVALUATION

This system is programmed such that it will sense and monitor the heartbeat rate whenever a fingertip is placed on the pulse sensor and triggers an alert by SMS messages sent to the mobile of the health personnel and also buzz an alarm whenever the critical threshold value of the heartbeat rate is exceeded.The table below shows the summary of the entire system performance as well as the tests carried out on the entire system to ascertain if it's working according to the desired objectives and specifications intended for it. The entire system is evaluated based on the tests, observations and results captured in the table below.

Table 1 System Performance And Evaluation

S/N	TEST	OBSERVATION	RESULT
1	INITIAL DISPLAY	DISPLAYS 'HEARTBEAT PROJECT'	SYSTEM ON
2	SIM CARD INSERTED	DISPLAYS 'WAITING FOR CONNECTION'	SEARCHNG FOR GSM NETWORK
3	FINGER PLACED AT THE SENSOR	DISPLAYS A VALUE	HEARTBEAT RATE DETECTED
4	NORMAL PULSE RATE	DISPLAYS A VALUE	NORMAL HEARTBEAT

			RATE
5	WHEN MSG IS SENT	DISPLAYS 'MSG SENT SUCCESSFULLY'	ABNORMAL HEARTBEAT RATE
6	MSG NOT SENT	DISPLAYS 'MSG NOT SENT'	MSG SENDING FAILED

A System Testing

This stage involves the testing of the whole system. After the integration of the whole units a test program was written and burnt into the microcontroller and then the system monitored to ensure optimum performance. The heart rate reading was displayed on the LCD in BPM.

B Packaging

Several factors led to the type of packaging adopted, which includes mechanical damage protection, moisture protection, portability, cost, convenience, etc. The packaging was carried out using a plastic material called Perspex or acrylic glass. The finished product is shown below:

FIG 8

Finished Product

CONCLUSION

Biomedical engineering (BME) is the application of engineering principles and techniques to the medical field. It combines the design and problem solving skills of engineering with medical and biological sciences to improve patient's health care and the quality of life of individuals. A medical device is intended for use in the diagnosis of disease, or in the cure, treatment, or prevention of diseases. Cardiovascular disease is one of the major causes of untimely deaths in world, heart beat readings are by far the only viable diagnostic tool that could promote early detection of cardiac events.

Wireless and mobile technologies are key components that would help enable patients suffering from chronic heart diseases to live in their own homes and lead their normal life, while at the same time being monitored for any cardiac events. This will not only serve to reduce the burden on the resources of the healthcare center but would also improve the quality of healthcare sector. This wireless

communications would not only provide us with safe and accurate monitoring but also the freedom of movement. For a patient who is already diagnosed with fatal heart disease, their heart rate condition has to be monitored continuously.

This work proposes and focuses on the heartbeat monitoring and alert system that is able to monitor the heart beat rate condition of patient. The system determines the heart beat rate per minute and then sends short message service (SMS) alert to the mobile phone of medical experts or patient's family members, or their relatives via SMS. Thus, doctors can monitor and diagnose the patient's condition continuously and could suggest earlier precaution for the patients themselves. This will also alert the family members to quickly attend to the patient.This system is cost effective and user friendly and thus its usage is not restricted or limited to any class of users. It is a very efficient system and very easy to handle and thus provides great flexibility and serves as a great improvement over other conventional monitoring and alert systems.

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