



GSM Based Patient Monitoring System

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Abstract: Health has become an important issue in today's world. People suffering from a disease or physical disorder might need their near ones and it is quite difficult for people to be continuously available for them. Most commonly people are suffering from Hypertension i.e., high blood pressure, Hypotension, low blood pressure, Diabetes, and many other diseases. Among India's population around 62 million people are suffering from diabetes in which 8.2 percent are adult male whereas 6.8 percent are adult female and this is increasing day by day. A major health problem in India is high blood pressure and the percentage of people suffering from hypertension ranges from 20-40% in urban adults and 12-17% in rural adults. Thus, the focus of this project is mainly on designing a system which measures blood pressure, pulse rate, body temperature of the patient. This paper deals with the design and development of a system that consist of different sensors such as blood pressure sensor, temperature sensor, heartbeat sensor and sugar level sensor these all are interfaced with the microcontroller which provides all these measurements to respective doctors with the help of GSM(Global Systems for Mobile communication). Also this paper shows that how the different health conditions of the patient are measured by microcontroller in real time and with the help of ADC these readings are converted into digital form. In this system GSM is used for mobile communication which means that all the readings are transmitted to the doctors PC through GSM network and then respective doctor will be able to access this information and further the patient's health is monitored. The design of this system is kept simple for home and ambulance use. This device is mainly designed for ambulance use and further it can be implemented in homes in rural areas. Efficiency of the proposed system is being demonstrated and it will be more efficient for doctors to check the patient as it gives real time information regarding to the patient's condition. To provide the medical services to the patients living in the rural areas of India, the use of telemedicine is one of the important concerns.

Key words: blood pressure, sugar level, microcontroller, mobile communication, pulse rate, real-time, body temperature.

1. INTRODUCTION

Since the goal of this project is to design and develop a device that is used to measure all the health conditions of the patient. This device makes use of different sensors to measure the different health conditions of the patient without the interference of even the patient himself. The system which has been discussed in this paper uses different sensors to detect the patient's health condition such as blood pressure sensor, temperature sensor, heartbeat sensor and sugar level sensor, a microcontroller, LCD, GSM. This system uses GSM (Global Systems for Mobile communication) technology. The GSM technology is used for transmitting and receiving messages to and from the respective person. The GSM technology is used for mobile communication via text, voice, etc. For digital cellular communication Global System for Mobile Communication (GSM) is a globally accepted standard. In 1982 GSM has been established to create a standard for European mobile telephone. The current most important user groups in the field of health monitoring are those aged 40 and more as compare to the younger people. The healthcare systems that uses wireless technology are more efficient and provides great mobility and increases the comfort level of patients [1][2]. By using wireless technology in healthcare systems it is possible to increase the quality of the system by means of providing easy access to those that are residing in rural areas [3]. The sensors that are used in present monitoring system are placed beside the monitors or PC and they are limited to the patient's bed. To overcome this disadvantage we used wireless network in modern devices. The Wireless Sensor Network are prominent technology in research now a days

which makes human life more reliable and it is known to have the ability to change the way of human life(make it more reliable and comfortable). In wireless network we have used different wireless sensors that has different advantages such as it supports large scale deployment, mobility, reliability, etc. This system will provide different health care services and communication between healthcare provider and the patient in emergency situations through SMS. If this system is used in the patient's home then it will send all the emergency physiological signals to the respective doctors without interrupting the patient's normal life. Thus, this will improve the life quality.

The proposed system uses different sensors that are interfaced with the microcontroller. These all sensors will take the corresponding measurement of the patients health condition continuously or at regular intervals and then sends it to the microcontroller. Microcontroller will accept these readings and convert it into the digital form and then send it to the LCD and GSM. In this system LCD is used for displaying purpose. Microcontroller will send this data to LCD to display the corresponding values and to GSM for communication with the doctor. GSM will send all this data to the doctor's PC in the form of text and doctor will be able to monitor the patient's condition. With the normal functioning of heart it requires an extended real-time observation to detect the heart's condition. Normally various diagnostic tests are done on the patient and then the doctor tells about the patient's condition. There are many different diagnostic tests that are used to check the patient's condition such as electrocardiography (ECG), ultrasonography (echocardiography), magnetocardiography (MCG) and magnetic resonance imaging (MRI) [4]. If the

patient is in the rural areas of India then it is not possible to diagnose all these tests. Therefore this advanced system is designed with the help of advanced sensors using wireless communication especially for the patients living in the rural areas, thus improving their life standard [5][6]. There are many villages and towns in remote areas of India, it is difficult for the patient residing in this area to do regular check up of their health condition due to lack of specialist doctors, lack of health care investments, inadequate medical services, high cost of medical services, etc [7][8]. Thus with the help of telemedicine all this problems can be solved. Telemedicine uses telecommunication technology which is used for communication between the health provider and the patients that are living in distant places. This modern device will be a solution to these all problems [9][10][11].

2. OVERVIEW OF THE SYSTEM

The aim of the project is to design a system which is uses different sensors to monitor the patient's health condition continuously or at regular intervals of time. This system uses a GSM (Global Systems for Mobile communication) technology which is used for the transmission and reception of data or information. This information or data can be in any form such as text, audio calls, voice messages, video calls, etc. Through mobile communication used by GSM all the measurements of different conditions of the patient are accessible to the respective doctors. All the data or information related to the patients are stored separately in the common database. The system improves the mobility of the device by making it more portable. In this proposed system the patients health conditions are continuously monitored and the data is sent to the centralized microcontroller using wireless sensor networks[12] A GSM is comparatively small and it can be connected to every patient monitoring system[13]. In this system different sensors measures the patient's health condition such as temperature sensor will sense body temperature of the patient, blood pressure sensor will sense the blood pressure of the patient, heartbeat sensor will calculate the pulse rate of the patient and sugar level sensor will detect the level of sugar in blood. All this data from these different sensors is collected and then sent to the centralized microcontroller through ADC. ADC will convert the analog signals into digital signals. Microcontroller will process all these signals and then send it to the LCD and GSM. LCD is used to display the corresponding values of the patient's health conditions. GSM is used for transmitting this data to the doctors PC , so that doctors will be able to access all the data related to the patient. Thus this system is useful for the communication between the doctor or the healthcare provider and the patient. In this system we can also set critical or threshold limits so that extreme or critical conditions of the patient can be directly sent to the doctor and also the buzzer is connected to this system turns on. With the help of this system the treatment time, cost and power consumption is decreased to a great extent. GSM will allow the doctors to be always connected with the microcontroller.

2.1 TECHNICAL APPROACH

A serial interface program is applied to accumulate the data from various wireless sensor networks to the central mobile monitor station running on microcontroller. The accumulated

data from various wireless sensors are managed by the controller intermittently. SMS alerts are created by the controller based on the preconfigured threshold values of the monitoring parameters of a specific patient. Another serial interface program is applied to interface with a standard GSM module on the controller. The SMS transmit and receive functionality is also implemented and it is amalgamated with a serial interface for a standard GSM mobile module [14].

3. SYSTEM ARCHITECTURE

The hardware design of WSN Gateway is depend on ARM microprocessor. The system is using PIC18F4520 microcontroller. There are total four inputs from the sensor to the system namely, temperature sensor, heartbeat sensor, blood pressure sensor. The system is sending and receiving data through GSM module through AT commands. [15]

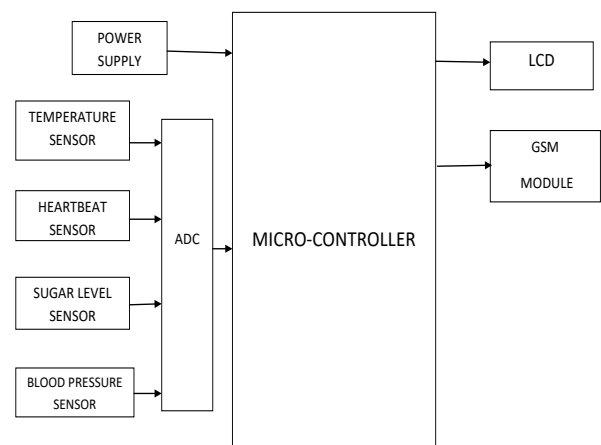


FIG. 1: BLOCK DIAGRAM FOR GSM BASED PATIENT MONITORING SYSTEM

4. HARDWARE MODEL

This system is made such that it takes many inputs which measures parameters such as temperature, blood pressure, heart beat. The biomedical monitoring system; microcontroller, sensors, GSM modem, power supply and Liquid Crystal Display are discussed here in this paper demonstrated [16]. The inputs are taken with the help of the sensors which are integrated and then are processed. The doctors can continuously monitor the condition of the patients in case of emergency and dangerous situations. The system will alert the doctor immediately in any emergency [16]. By using GSM module, the outputs are transmitted to the doctor's mobile.

4.1. Temperature sensor

To examine the health of patient, body temperature is an important aspect. During any kind of medical examination, doctors first check the temperature of patient. So it becomes very useful for the doctor to determine patient's health condition by sending body temperature's information.

TEMPERATURE sensors are commonly used in measurement, instrumentation, and control systems. In various operations, it becomes easy and draws attention if we use temperature sensors that give explainable temperature reading in digital form. In this system we are using a LM35 sensor

[17] which is made up of semiconductor material which senses the patient's body temperature. The LM35 is an integrated circuit sensor which is used to check temperature which gives an electrical output equivalent to the temperature. The output voltage is not supposed to be increased since LM35 produces a very high output voltage as compared to thermocouples. The scale factor is $0.01\text{V}/^\circ\text{C}$. The benefit of using temperature sensor is that outside lining up is not needed and keeps up an accuracy of $\pm 0.4^\circ\text{C}$.

4.2. Blood pressure sensor



Fig 2. Blood Pressure Sensor

Blood pressure is the force of the blood in the arteries since the blood is carried all over the body with the help of heart. When the heart beats, it compresses and transports blood to all over the body through the arteries. Because of high blood pressure serious problems may arise like heart attack, stroke or kidney disease. Usually high blood pressure does not have any symptoms, therefore blood pressure of patients need to be monitored continuously.

There are several drawbacks in devices which are used now-a-days for blood pressure determination. To achieve single measurements at a rate of some Hertz, outside methods depend on hand cuffs or other pressurized devices.

Using these devices it is not possible to continuously check the blood pressure of the patients. Therefore one is supposed to use the intravascular pressure sensors which record the blood pressure continuously [18]. Because of the internal excess pressure, intravascular pressure sensors determine the displacement of surface caused by the movement of a blood vessel wall. But this leads to very heavy solutions [19][20]. Following table shows the standard values of Blood pressure for adults [21].

TABLE I. CLASSIFICATION OF BLOOD PRESSURE FOR ADULTS (18 YEARS AND ABOVE) [21][18]

Parameters	Systolic (mm Hg)	Diastolic (mm Hg)
Hypertension	<90	<60
Desired	90-119	60-79
Pre hypertension	120-139	80-89
Stage 1 Hypertension	140-159	90-99
Stage 2 Hypertension	160-179	100-109
Hypertensive Crisis	≥ 180	≥ 110

In this system infrared LED is used as a transmitter and an infrared photo-transistor is used as a receiver which works as a

fingertip sensor. Detector has a super bright red LED and light detector. The LED should be super bright so as to pass maximum light through the finger so that it will get detected by detector. When blood flows through the blood vessels, the finger turns slightly opaque therefore less light outreaches the detector. The detector signal varies with every heart pulse. This change is converted into electrical pulse. And the signal is increased with the help of an amplifier whose output is an analog voltage between 0 to 5V logic level signal. High blood pressure, which is also called as hypertension, occurs when the pressure of blood in the artery walls is increased, causing more strain on the blood vessels [20]. The sensor used in this project is FGN type pressure sensor. FPN/FGN (Gauge) Package (8 mm tube length) mili volt uncalibrated output. The FPN is a dual in-line package and the FGN gives a surface mount package.

4.3. Heartbeat sensor



Fig.3 heartbeat sensor

One of the important routine examinations includes pulse rate. It is not only necessary for cardiac patients but it also helps doctor to understand patient's health condition. The heart rate of a healthy adult [19-20 age groups] is about 72 beats per minute (bpm). Athletes usually have lower heart rates. Babies have a much higher heart rate at about 120 bpm, while older children have about 90 bpm. The heart rate rises slowly during exercises [21] and falls gradually to the rest value after exercise. The statistics related to pulse is also useful if it is corresponding with the current or past problem of the patient which is known to the doctor. In this system we are using an IR sensor. Since Infrared is very well absorbed in blood and absorbed slightly in body tissues. Any change in the volume of blood can be calculated since rise and fall of volume will cause more or less absorption and blood volume changes in between the heart beats.

As people's living style and standard is improving day by day, the cardiovascular disease is rising year by year, and is now the second reason of death among the urban and rural people [22]. Hence, heart rate is getting noticed from medical field in recent years [23][24] and should be checked properly in any patient monitoring system.

The IR LED (infrared LED) is kept above the finger. It is kept above finger as fingertip allows an easy flow of IR through it and therefore a photo transistor is kept just below it. The variation in voltage of photo transistor is very low therefore it needs amplification and removal of noise to withdraw the environmental noise.

The TABLE 2 [25] shows the normal pulse rate range of human with their age. The table shows the pulse rate falls with rise in age and get constant at a certain age.

The system also has the advantage of emergency alarm generation is that it will automatically send SMS in case of any abnormality in pulse rate. The doctor should take quick action regarding this information. It will save crucial time of patient's life. Following table has the standard values of normal pulse rate [26].

Table II. NORMAL PULSE RATE [25][26]

Newborn	1-12 months	1-2 years	2-6 years	6-12 years	12 years-adults
120-160	80-140	80-130	75-120	75-110	60-100

4.4. GSM network

The major part of this system is GSM network. With GSM (2G network) which is very fast, messages can be sent very easily and quickly. When emergency occurs the connection between doctor and patient is mandatory. Wireless networks that serve mobile customers by fixed base stations such as cellular networks have to keep track of those mobile customers to make sure appropriate service delivery [27].



Fig. 4 GSM Module

The longest official distance GSM specification supports is 35 km [28].

GSM network service also called as High Speed Circuit Switch Data Service (HSCSD). It gives data services up to 57,6 kbps of speed, which depends upon multi slot usage. Also some advanced operators are going to launch a new data service which is General Packet Radio Service (GPRS) this year. The range of data communication speed in the first phase can be achieved at 9.1 to 40.2 kbps, using different coding schemes. In GSM system, the services such as short message

service and set of value added services are also enumerated[28].

High speed data exchange between two mobiles is provided by GPRS system through a protocol which is designed by packet on a no. of traffic channel circuit. The small data can be sent within few seconds and the data is exchanged at the speed of about 256 kbps. GSM Subscribers can send messages that can be text, images or video, and audio. This is provided by MMS technology. MMS technology provides more real and lively experience to patients, as it contains media data in form of video and audio. The mobile phone models in the market are capable of sending MMS, so that the patient's information can be send using MMS system. The special software is necessarily used to send sound of heart beat. Different sensors are attached to the system with GSM phone based on smart GPRS, which is used to create MMS and send it to the phone [29]. Mobile gets data from the microcontroller by using F-Bus and MMS can be created by combining it. Mobile receives the MMS (text). The bandwidth assigned for the use of GSM in 1800 MHz frequency band is three times of the bandwidth specified to primary GSM in frequency band of 900 MHz. In 1800 MHz band also the reserving frequencies aimed to meet the requirements of increasing capacity [30]. The modulation scheme is the combination of FDMA (frequency division multiple access) and TDMA (time division multiple access) which can be defined by the physical layer of GSM [28].

5. PATIENT UNIT

The unit which is very near to patient, examines the various values w.r.t pulse rate, body temperature and blood pressure is known as patient unit. By using this section of the entire system the information can be send to doctor. This system is movable and can be carried to any location or used by person sitting near the patient. Three different sensors such as temperature sensor, blood pressure sensor, heart beat sensor are used to sense these physical quantities and convert them into electrical signals. One of them is a temperature sensor i.e. LM35 is used for sensing body temperature, etc. [31][32].

6. RESULT

This system accepts several inputs and calculate human parameters i.e. temperature, heart rate, Blood pressure. This system consist of microcontroller, different sensors such as heart beat, blood pressure, temperature sensor, GSM module, power supply (5v) and LCD (16*2). The values from different sensors can be displayed on the LCD. The threshold value has been set, if the person is medically ill or the value exceeds the threshold value, then the buffer is on. The processing of all the inputs from the sensors can be done. The doctor can continuously monitor the condition of the patient and when the crisis or dangerous situations occur, doctor will get message immediately. GSM module accepts the results and sends it to the PC or mobile phone. Using serial interface program the data can be collected from the three sensors at the central mobile monitor station. Then the processing of data occurs periodically. Microcontroller sends an alert message when the

value of parameters of the patient exceeds beyond the threshold value.

Table III. REAL TIME READINGS OF PATIENTS

Name	B.P Sensor	Heart Rate	Oximeter	Temperature
Patient1	90	81	94%	35°
Patient2	95	80	91%	33°
Patient3	105	82	95%	36°

7. CONCLUSION

In this proposed system we have used different sensors that are interfaced with the microcontroller and studied different functions of these sensors. These all sensors will take the corresponding measurement of the patients health condition continuously or at regular intervals and then sends it to the microcontroller. Microcontroller will accept these readings and convert it into the digital form and then send it to the LCD and GSM. In this system LCD is used for displaying purpose. Microcontroller will send this data to LCD to display the corresponding values and to GSM for communication with the doctor. GSM will send all this data to the doctor's PC in the form of text and doctor will be able to monitor the patient's condition. In this we studied GSM and it's AT commands. Microcontroller sends an alert message when the value of parameters of the patient exceeds beyond the threshold value. The accuracy of the system is 90%. Thus, the system is accurate and verified.

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