



## Development of a GSM Based Health Monitoring System for Elderly People

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### ABSTRACT

Advancement in wireless communication has set a new paradigm in healthcare management system which is based on sensing vital physiological parameters, collection of data and transmission of that data in real time and with optimum precision. Going to the hospital every day for medical checkup can be tiresome, stressful and it also brings about the problem of congestion of hospital space and beds. Lack of human resources at the hospital aids the congestion of hospital space. This paper is based on monitoring physiological parameters of elderly people. A reliable and cost effective GSM based health Monitoring System is developed in this paper. The result obtained showed that the system is reliable and efficient with an average sensitivity of 0.5 seconds and response time of 6 seconds. The system is able to monitor heartbeat and blood pressure and send the data in real time to the mobile phone of the doctor. It enables the doctor to keep track of his patient's health.

**Keyword:** GSM, Health Monitoring, Elderly, Wireless Communication, Body Area Network.

### INTRODUCTION

Health monitoring of elderly people has been an issue for healthcare sector over the years because they are more prone to chronic diseases and require regular checkup. According to [1] the population of elderly people above the age of 65 years across the world is more than 650 million people and this large number will double in the next decade. Health monitoring has been faced with problems such as the lack of human resources to attend to patients, patients' information not easily accessed by their doctor, congestion of hospital space and beds. Health monitoring systems make use of biomedical sensors which continuously and in real time check for various physiological parameters of the patient. For proper management of healthcare, patients need to be educated on how to manage their health. Quality and healthy life style include good support of human health monitoring and assessment [2].

Advancement in technology contributed immensely to healthcare management. Modern Intensive Care Units have presented an outstanding range of technologically sophisticated instrumentation to produce a broad measurement of the physiological state of each patients. A number of bio-sensors that monitor physiological signs, environmental conditions (temperature, humidity and light), and a location sensor can all be incorporated in a wearable wireless body area network. Body area networks are inexpensive, have light weight, offer long-term, unobtrusive, ambulatory health monitoring in real time. In order to keep track with patients health status a health monitoring system based on GSM is designed and implemented in this paper. The system will be applicable in remote areas such as villages where the indigenes are out of reach from experienced physicians and the city.

This paper is structured as follows. Section 2 presents the review of related works while the model architectural design is presented in section 3, and the performance evaluation of the model was carried out in section 4. Section 5 concludes the paper.

Numerous authors have worked to achieve a standard health monitoring system. [3] developed a GSM Based Heart Rate and Temperature Monitoring System for continuous monitoring of the patient condition especially in the case of old people who are suffering with heart diseases or cases where the patient location is far away from the hospital. The system measures the heart beat of the patient using a parallel arrangement of LEDs and LDRs which harnesses the systolic pressure qualities of the finger tip, also an LM35 is used to measure the temperature which are then transmitted through a GSM modem to the doctor or medical center. The system provides a low cost solution by utilizing the AT89S52 Microcontroller, however, the system lacked redundancy in case of network downtime.

[4] also developed a mobile health monitoring system that uses the GPRS technology. With the advent of Personal mobile devices which is becoming more equipped with information management, processing and sharing tools it presents a very good opportunity for the development of a mobile, user friendly and unobtrusive health monitoring system. Specifically, the system unlock existing ones resident and added Intensive Care Units of hospitals. It is mobile, it measures patients body temperature and heartbeat, compares it to a previously determined values, if extreme values are detected the system relays the information to a nearby mobile phone which then sends an SMS to the doctor containing the parameter readings and location information via gprs. The system does not measure blood pressure reading which is very important. [1] proposed an improved Remote Patient Monitoring (RPM) systems equipped with wireless capabilities. The system is expected to monitor patient's vital signs and transmit them via wireless channels like Bluetooth, zigbee or other Wi-Fi link to the doctor's mobile phone along with a camera enabled live feed of the patient's condition. Unlike previous works, this proposal is not cost effective and it is expected to be used within a short range. It

utilizes a readily available AVR microcontroller and IDE. An attached server unit is expected to also receive all sensor data, process it and store before sending the information to the doctor. This storage functionality is a very vital improvement. Meanwhile, [5] developed Wireless Biomedical Sensor Network for Home-based ECG Monitoring system. This system utilizes a mote platform for Wireless Biomedical Sensor Network (WBSN), named Telekom Research Group (TRG) mote that complies with IEEE802.15.4 standard and operates in 2.4 GHz ISM band. The platform is designed by hardware and software implementations. Since energy consumption is a major concern for any wireless sensor network, the mote design utilizes a low power 8-bit PIC18F452 microcontroller and XBee wireless transceiver module. This system measures only heartbeat rate and is highly expensive.

[6] developed a system based on continuous monitoring of ICU patients. The system is a reliable, energy efficient patient monitoring system. It is able to send parameters of patient in real time. It enables the doctor to monitor patient's parameters (temperature, heartbeat and ECG) in real time using http protocol. The timely manner of conveying real time monitored parameter to doctor is given highest priority. The system is not cost effective and does not monitor blood pressure which is a vital parameter.

Our proposed model for GSM based health monitoring system improves on the deficiencies in [3], [4] and [6] by using a buzzer to checkmate the problem of network downtime and blood pressure sensor was incorporated into the system for blood pressure monitoring. The developed system monitors blood pressure and heartbeat rate in real time with optimum precision.

## METHODOLOGY

### System Design

The model as shown in Figure 3.1 interfaces a GSM module with sensors (heartbeat and blood pressure) for real time monitoring of patients physiological status. The operation of the system is such that the sensors send signals to the microcontroller which then interpret the signals and send the output to the mobile phone of the doctor. The standard values are already stored in the microcontroller so if there is any abnormal reading, the buzzer incorporated in the system will ring an alarm and an SMS will be sent to the mobile phone of the doctor. The system functions with both AC and DC supply.

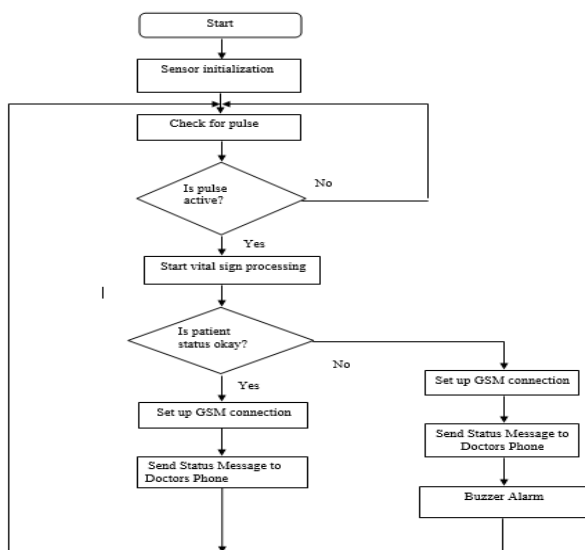


Figure 3.1: Flowchart of the System

The flowchart in Figure 3.1 describes the entire operation of the system. The transmission unit houses the GSM module which is configured using AT commands. It is connected to RC6 (TX) and RC7 (RX) of the microcontroller serial input and output ports/pins and these enable the microcontroller to send SMS to the designated recipient the input readings from the sensors. A SIM900 GSM module was used for this project because of its availability. The transmission unit also housed an LED. The status LED consist of an LED connected to PortB0 of the microcontroller. This is used to indicate that the system has sent an SMS. The sensor unit of this system comprised of LM358 IC and a 555 timer. The 555 timer was used for pulse generation while the LM358 IC was used for amplification and as a comparator. The LM358 amplifies the sound from the heartbeat and the variation of the beat. It has dual low power amplifier. When the heart beats, a pressure wave moves out along the arteries at a few meters per sound. This pressure wave can be felt at the wrist, but it also causes an increase in the blood volume in the tissues which can be detected by a 555 timer. The amplified signal from the LM358 to the microcontroller is then converted by the ADC and the calculation is performed by microcontroller. Filtering is needed to block any higher frequency noise present in the signal. The software used serves as the domain for the control of the hardware. It is the set of instruction that is used to configure the hardware. The control program for this model was written in CCS language. The CCS program implements the flowchart described in Figure 3.1. Simply put, it reads in binary patterns from the input system and sends out binary patterns that would cause the required actions to be taken by the output system.

### System Hardware

The hardware system comprises of different units which perform different functions to meet the objectives of the system. The units are: The power unit, the sensor unit, transmission unit and the Control Unit.

**Power Supply Unit:** The power supply unit is used to provide regulated DC voltages for electronic circuits. A 12V Transformer was used to step down 220V from the mains to 12V which is connected to the rectifier that converts the 12V A.C to D.C. A capacitor (Electrolytic) of 10uF 50V is used to filter A.C ripples from the D.C. Regulator (7805), regulates 12V DC to 5V DC for use by the microcontroller and other components. The choice of the transformer for the power supply unit was decided based on the following: Output Voltage (to the load) = 5V DC since a 7805 voltage regulator was used. Diode voltage drop = 0.7V per diode.

$$\text{Transformer losses} = I \cdot I_v$$

$$\text{Therefore, minimum input voltage} = (5 + 2.5) V = 7.5$$

The block diagram of the power supply unit is shown in Figure 3.2. But again this system uses a 9V battery as the power source through the power supply so that the system will remain on and working even if the ac power source is gone or unplugged the dc power through the 9V battery will keep the system functionality on until the power in the battery is drained.

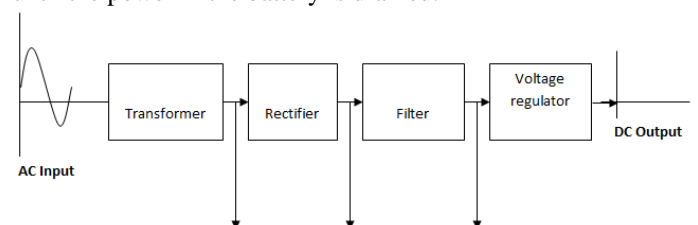


Figure 3.2: Block Diagram of Power Supply Unit

**Sensor Unit:** Transducers are used for measurement of electrical, thermal, mechanical and chemical properties. A transducer is any device that convert non-electrical signal into electrical signal (voltage or current) that are proportional to the value of the physical parameters being measured. Transducers are divided into two classes namely: sensors and actuators. Sensors are devices that sense, detect or measure real-world conditions such as heat, light and convert it into an analogue or digital representation. The sensor unit of this system comprised of LM358 IC and a 555 timer. The 555 timer was used for pulse generation while the LM358 IC was used for amplification and as a comparator. The LM358 amplifies the sound from the heartbeat and the variation of the beat. It has dual low power amplifier. When the heart beats, a pressure wave moves out along the arteries at a few meters per second. This pressure wave can be felt at the wrist, but it also causes an increase in the blood volume in the tissues which can be detected by a 555 timer. The amplified signal from the LM358 to the microcontroller is then converted by the ADC and the calculation is performed by microcontroller. Filtering is needed to block any higher frequency noise present in the signal. The amplification circuit is shown in Figure 3.3.

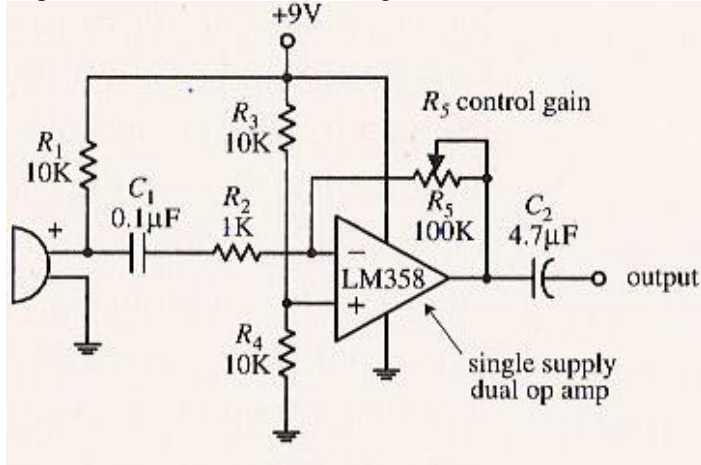


Figure 3.3: Amplification circuit

**Transmission Unit:** The transmission unit houses the GSM module which is configured using AT commands. It is connected to RC6 (TX) and RC7 (RX) of the microcontroller serial input and output ports/pins and these enable the microcontroller to send SMS to the designated recipient the input readings from the sensors. A SIM900 GSM module shown in Figure 3.4 is used for this work because of its availability and functionality.



Figure 3.4: SIM900 GSM Module

The transmission unit also houses an LED. The status LED consist of an LED connected to PortB0 of the microcontroller. This is used to indicate that the system has sent an SMS. The circuitry below shows how the LEDs are connected and how the limiting current resistor value is obtained is shown in Figure 3.5.

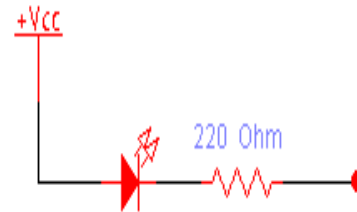


Figure 3.5: LED Indicator Circuit

The forward voltage drop of LED's is 2V and forward current of 13.6mA. From Ohm's law, Therefore,  $R = 220.5 \text{ Ohm's}$ .

**The Control Unit:** This unit controls the system. It collects signals and directs the operation of the output unit by providing the timing and control signal. The control unit used in this research is PIC16F887 microcontroller with 40 pins shown in Figure 3.6. The overall circuit diagram of the system designed is shown in Figure 3.7.

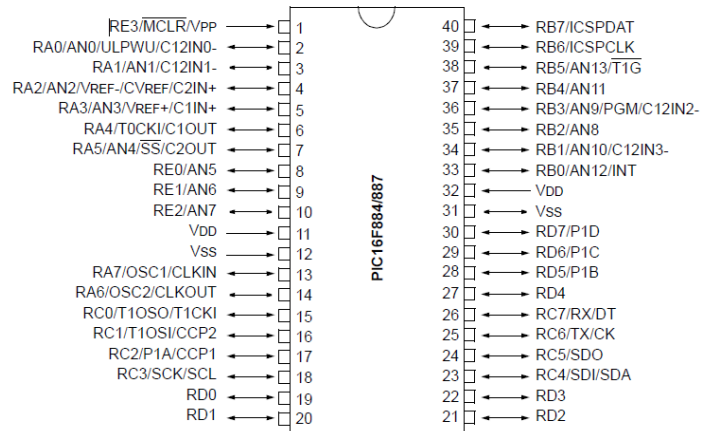


Figure 3.6: Pin Diagram of PIC16F887

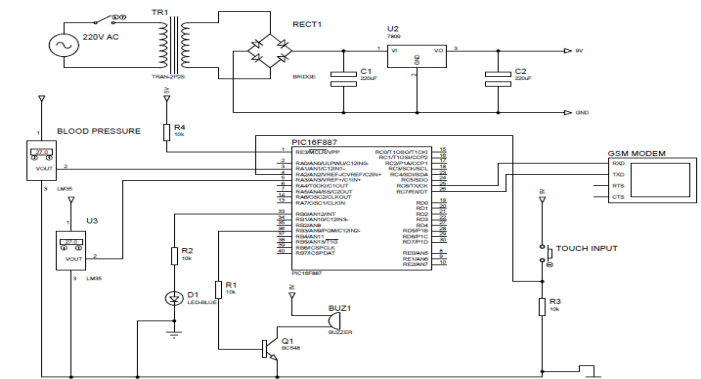


Figure 3.7: Circuit Diagram of the System

### System Implementation

The system is firstly simulated on a breadboard for design adherence and performance check before implementing it on a Vero board. The system is packaged using glass Perspex. Figure 3.8 shows the finished product being tested.

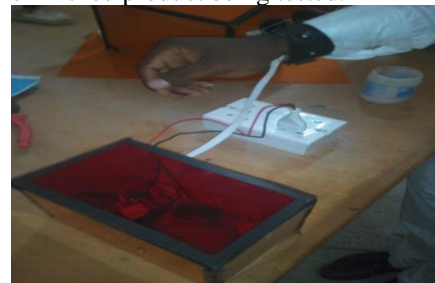


Figure 3.8: Snapshot of Developed Module

## TESTING AND RESULT

Evaluation of the system is based on sensitivity, accuracy and response time to determine the reliability and efficiency of the system. Testing for sensitivity is to define how long it takes the system to respond to changes in physiological data and how fast it detects pulse, while, accuracy measures the closeness of the values obtained by the system to standard values for a healthy person. Response time deals with the length of time it takes for the

message sent to get to the recipient. Table 1 shows the results obtained for 4 different sample runs from different individuals using two systems for Heart Beat Rate and Blood Pressure. The error rate is calculated from the raw data using:

$$\text{Formula for error \%} = \frac{(\text{project reading} - \text{existing system reading})}{(\text{existing system reading})} \times 100$$

Table 1. Result Obtained

Test	Project (BPM)	Existing System (BPM)	Error Rate (%)	Project (mmHg)	Existing System (mmHg)	Error Rate (%)
Sample 1	72	73	1.37	101/60	103/62	2.59
Sample 2	76	80	5.00	100/63	101/62	1.30
Sample 3	67	69	2.90	107/72	106/73	1.16
Sample 4	81	84	3.57	115/70	117/73	2.91

It was observed that some readings vary due to some factors like unstable power, movement of the body when the sensor is placed on the users' wrist. From the percentage error derived from the readings, the system is efficient and suitable for use. The sensitivity reading shows how sensitive the sensor is and how fast it collects pulse. The response time readings indicate that the time it took to for the SMS to deliver was fast. Figure 4.1, 4.1 and 4.3 shows the relationship between the results obtained from the developed system and an existing system. The closeness of both results indicates that the developed system is highly efficient.

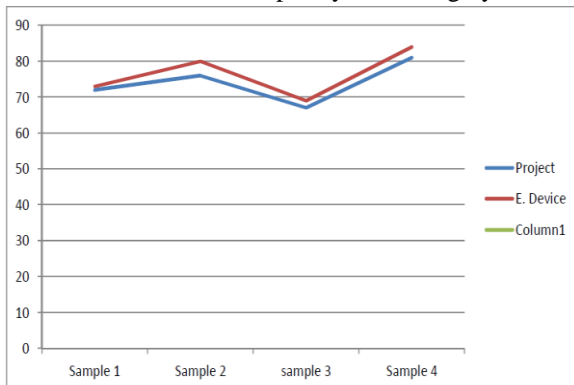


Figure 4.1: Graph Comparing Heart Beat Rate Readings from both Devices

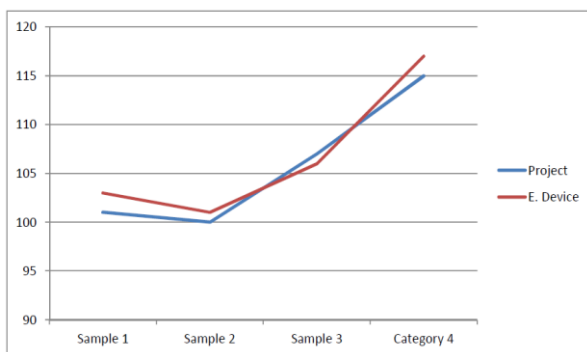


Figure 4.2: Graph Comparing Systolic Blood Pressure Readings from both Systems

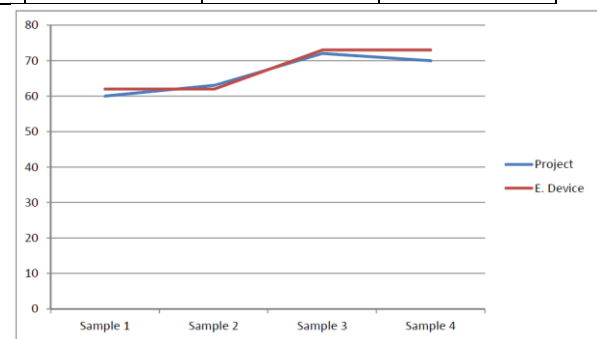


Figure 4.3: Graph Comparing Diastolic Blood Pressure Readings from both Devices

## CONCLUSION

The health monitoring system implemented in this paper seeks to eliminate the stress of going to the hospital frequently for checkup, congestion of hospital space and beds. It monitors blood pressure and electrocardiogram and transmit the information to the mobile phone of the doctor via SMS in real time. The results obtained shows that the system is efficient and reliable. The system is cost effective and has ease of use.

## RECOMMENDATIONS

Future researches should look at the following open issues:

- ❖ Enhancement of the system to sense additional physiological parameters other than blood pressure and heart beat rate.
- ❖ A network booster could be incorporated in the system to aid the transmission of data via SMS.
- ❖ A graphical user interface could also be implemented for better user interaction with the system.
- ❖ Also a non-proprietary platform should be explored to ensure more reliability and cost effectiveness.

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