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# Development of a Portable GSM SMS-Based Patient Monitoring System for Healthcare Applications

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*Abstract-* Although health care is a vital problem, in recent years mobile communication has become a widespread part and parcel of everyday life even in the rural areas of developing countries. This paper proposed a model to include the mobile communication for monitoring vital signs of health such as blood pressure, heart rate, body temperature; blood glucose level and sends result as Short Message Service (SMS) for the physician so as to monitor their patients continuously. Cuffless pressure sensing transducer is taken into consideration to measure pressure pulse and then combined with oscillometric method to measure Blood Pressure (BP). Availability of different sensors and measurement techniques to determine heart rate is presented. Conventional glucometry in low cost electronics and body temperature measurement using electronic thermistor is also described here. Sensed parameters are processed and stored into an array in ARM7 processor and sent via GSM SIM300 Modem. This portable vital sensing system is useful to analyze daily health condition; can be used both in home and hospital to prevent Hypertension, Heart Attack and to control Diabetes.

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*GJCST-G Classification: J.3, C.2.2*

DEVELOPMENTOFAPORTABLEGSMSMSBASEDPATIENTMONITORINGSYSTEMFORHEALTHCAREAPPLICATIONS

*Strictly as per the compliance and regulations of:*

# Development of a Portable GSM SMS-based Patient Monitoring System for Healthcare Applications

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## I. Introduction

The use of mobile phones has grown exponentially over the last few years in the developing countries [1]. But healthcare issue remains a vital problem and health monitoring in home is not possible without visiting a physician. The heart, cardiovascular and hypertension diseases are the Top 10 Causes of Death [2]. The blood pressure can be an early evaluation index of cardiovascular disorders. Another most common chronic disease among the elderly is the Diabetes. Regular monitoring of vital signs such as blood pressure, heart rate, body temperature, breathing rate and glucose measurement for diabetic patient is essential as they are primary indicators of an individual's physical well-being. One of the advantages for both patients and physicians is that there are many devices available in the market today that allow patients to monitor their own health on a regular basis from the comfort of their home.

A home medical care system to monitor vital signs consisting of a computer and requires internet connection [3]. This system can provide a number of healthcare services for those living in remote areas. Real time health monitoring for ICU patients has also been designed [4]. This system is mainly based on continuous monitoring aspect of ICU patients which enables the doctors to monitor patient's parameters (temp, heartbeat, ECG) in real time using http protocol. Wireless blood pressure measuring system with a Zigbee wireless transmission module and a PC based management unit requires complex graphic user interface and database [5]. These systems are costly and computer based, also not easily portable and uses internet for data transfer; which is not available in rural areas and requires expert to operate. So the objectives of this paper is to design a model of a portable health monitoring system that investigates users blood pressure , heart rate, body temperature an blood glucose level; which is low cost, consume low power, easy to operate and transfer data using SMS of mobile phone communication.

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## II. Proposed System

The proposed system consists of several blocks that perform the sensing of different health parameters. These measured data received by a 32 bit processor ARM7; where different signal conditioning and processing task performed. The complete system block is shown in Figure.1.

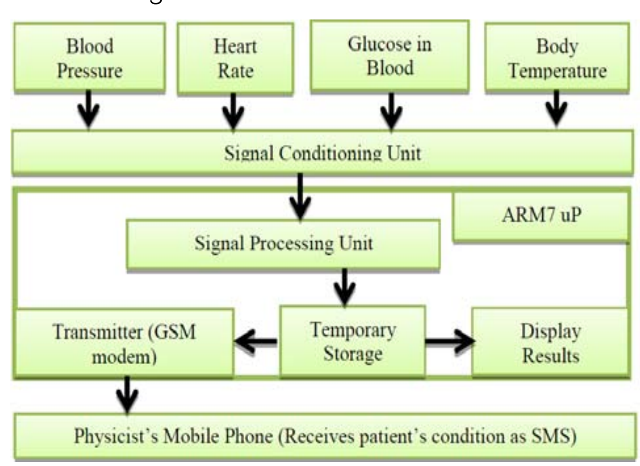


*Figure 1 :* Complete block diagram of the proposed system

Using the built-in ADC of ARM7 microprocessor analog results are converted and displayed using an appropriate display and also sent to the GSM modem through which an SMS is sent to the previously entered physician's mobile phone.

## III. Hardware Design

### a) *Blood Pressure Measurement*

Traditionally air cuff is used to measure blood pressure. But recently certain technology has been developed to measure the blood pressure accurately and automatically without cuff. Cuffless BP measurement techniques based on pulse transit time (PTT) and wavelet transform have been studied [6]. PTT refers to the duration for a pressure pulse to travel between two measuring sites in the arterial system. In order to predict Blood Pressure (BP), these techniques have to measure multi-points of the body and therefore patients may feel uncomfortable. Also, they need both the electrocardiogram (ECG) and the photoplethysmography (PPG) and introduce problems in accuracy. Applied pressure (APm) which has the maximum pulse pressure, was proposed as an alternative to PTT for predicting BP, especially mean arterial pressure (MAP) without cuff. To make the model user friendly and easily portable this model takes one such method developed using silicon rubber constructed over the pressure transducer (MPS-3117, Metrodyne, Taiwan) [7].

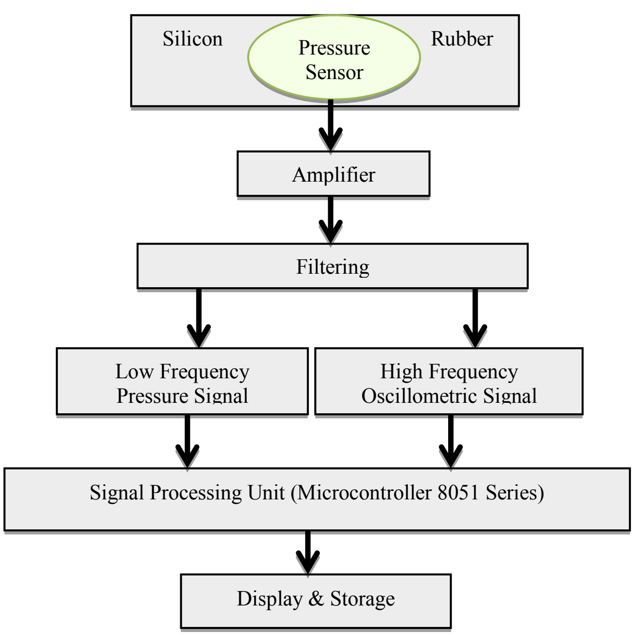


*Figure 2 :* Cuffless Blood Pressure Measuring System

The cuffless pressure sensing module was constructed by enclosing a blood pressure transducer into a silicon rubber doom. As the silicon rubber is airtight and elastic, the pressure signal can conducted into the pressure transducer with little distortion. The signal obtained from the pressure sensor is amplified and filtered by the signal conditioning circuits. Fig.2 presents the schematic diagram of the cuffless blood pressure measuring system. The signal conditioning hardware separates the pressure signal into two components, the low frequency pressure signal and the high frequency oscillometric signal, before passing them to the signal processing unit. In signal processing unit after the essential digital low pass filtering, the digital signal unit detects the maxima and minima in each and every heart beats, from the oscillometric signal, in order to determine the magnitude of pulse pressure. The corresponding pressure readings are collected and sorted. At the same time the pulse pressures are rearranged according to their pressure reading values. Out of the rearranged pressure waveform (oscillometric waveform), systolic and diastolic pressures are deducted through a mathematical algorithm which is firm dependent. The mathematical algorithm consists roughly of two parts: a preprocessing part to smooth the signal and an optimization part to compute the systolic and diastolic pressures [8]. During the measurement, the user holds the cuffless sensing module in one hand and place the silicon doom on top of the radial artery on the other hand [7]. To maintain the applied pressure onto the radial artery increasing as linear as possible is necessary; which is one of the disadvantages of this system. For slowly applied pressure, the applied pressure did not reach the systolic pressure and the determination of systolic pressure was not possible. On the other hand, when the pressure was applied too fast, the number of heart cycle in the measurement period was inadequate. Although this process is not accurate but this eliminates the use of cuff in which a trained physicist would needed to measure. Some advance signal processing technique may eliminate the inaccuracy. To obtain improved blood pressure estimates [9] the breathing signal is extracted from the oscillometric (OMW) signal and validated. When the OMW is strongly influenced by the breathing signal, a homomorphic filter is applied. Then an adaptive scheme is used to suppress the effects of the breathing signal and the output of this signal is used to obtain the blood pressure estimates.

### b) *Heart Rate Monitoring*

Heart attack has become the number one killer in many countries. However, if help is given within 10 minutes of an attack occurring, there is a chance that heart attack will not cause death [10]. In detecting a heart attack, one of the early symptoms is irregular heartbeat. The heart rate or pulse rate is the number of heart cycles that occur every minute [11].

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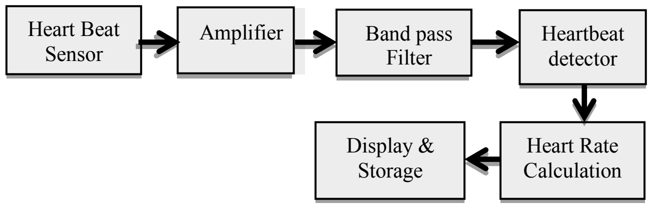


*Figure 3 :* Generalized block diagram for heart rate monitoring

A heart beat monitor has to take readings of the systole and the diastole which occur every 0.30 and 0.55 seconds [12], respectively in order to determine a heartbeat pattern. A sensor that can [13] detect the small displacements associated with the arterial pulse can be used in this application. A piezoelectric sensor pressed against the wrist over the radial artery will detect the arterial pulse or a strain gauge in a mechanical structure that would convert the pulse to a varying strain in the sensor can be used here. A tissue that has a high capillary density will have a significant change in volume over the cardiac cycle: its volume will be greater during systole and less during diastole. Therefore, any sensor that can detect change in volume in biologic tissue could be used to detect the peripheral pulse. Now a signal containing information about the peripheral pulse or heartbeat is detected, the next step is to recognize each heartbeat and to determine the heart rate. This is done by the signal processing block of the instrument shown in Fig.3. The first step of the signal processing is to amplify the signal to a level where it can be processed. The signal is then filtered by a band pass filter that helps to minimize noise and interference that could lead to errors in heartbeat detection. After the heartbeat detector, the next step in the signal processing is to determine heart rate, counting the detected beats and display and/or store the results. Since physician measures heart rate in beats per minute, the interval between beats is often converted to heart rate using the formula,

$$\text{Heart rate in beats per minute} = \frac{60{,}000}{\text{beat interval in miliseconds}}$$

Average heart rate can be displayed as an analog or digital quantity which has its corresponding advantage and disadvantages.

*c) Blood Glucose Level Measurement*

Diabetes mellitus is a common health problem throughout the world. It prevents the body from producing enough insulin (hormone produced in the pancreas). According to the World Health Organization statics, the global prevalence of diabetes mellitus is approximately 155 million people and expected to increase to 300 million[14] in the year 2025. Glucometry is a technique that obtains the value of glucose concentration in peripheral or central blood to determine metabolic disorders such as diabetes mellitus, denutrition, and other consequences like hyperosmolar coma, malabsorption syndrome, and mostcritical hypoglycemia. A glucometer and proper pharmaceutical treatment is fundamental for glycemic control of diabetic patients [14].

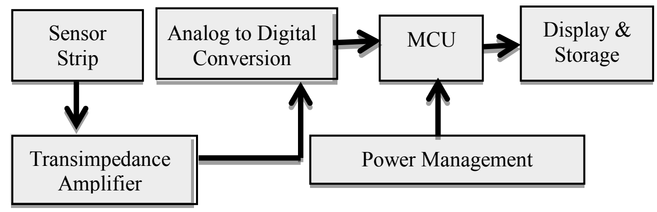


*Figure 4 :* Connection diagram of glucometer

To measure the glucose in the blood firstly the glucose concentration is converted into a voltage or current signal, this is possible with special sensor strips for amperometry. The sensor uses a platinum and silver electrode to form part of an electric circuit where hydrogen peroxide is electrolyzed.

Glucose+Oxygen→Gluconoic Acid+Hydrogen PerOxide

The hydrogen peroxide is produced as a result of the oxidation of glucose on a glucose oxide membrane. The current through the circuit provides a measurement of the concentration of hydrogen peroxide, giving the glucose concentration. Current produced must be changed to voltage for processing by the microcontroller (MCU) in Fig.4. This action is performed by the transimpedance amplifier. Finally, the MCU detects and processes this signal with the ADC module and displays the glucose concentration in blood.

*d) Body Temperature Measurement*

Body temperature is one of the vital signs that are the indicators of human being's overall physiological states [15]. Human body temperature varies within a narrow range of values. Variation of temperature depends on many things, including level of activity, time of day, and psychological factors. One of the most accurate types of body temperature measurement incorporates the measurement from ear [11]. As the temperature sensor a non-linear thermistor with tolerance of ±0.2°C can measure temperatures ranging from 0°C to 50°C and has a fast response time and low power dissipation, which makes it ideal for such medical application. Thermistor based body temperature measurement depicts in Fig.5.

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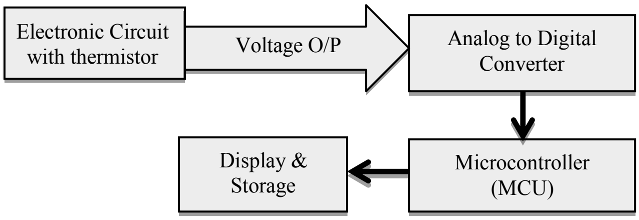


*Figure 5 :* Connection diagram of thermistor based body temperature sensor

The output voltage can range from +2.5 V to -2.5 V. Change in temperature causes the thermistor's resistance to change accordingly. The relationship between this thermistor's resistance and temperature is non-linear. When the thermistor's resistance changes due to change in temperature, the output voltage will change. Wheatstone bridge can be used that accurately measures small changes in resistances and produces a voltage output. This voltage output is sent through an ADC into the microcontroller. Inside the microcontroller, there is a table stored in EEPROM that has temperature values corresponding to voltage values. From this lookup table, the body temperature in degrees Celsius is determined.

## IV. Communication between GSM Modem & Mobile Phone

### a) *ARM7 Microprocessor*

The ARM7TDMI-S is a general purpose 32-bit Reduced Instruction Set (RISC) microprocessor, offers high performance and very low power consumption [4]. The programming of ARM7 can be done using various programming software like Keil uVision4.

### b) *GSM Modem*

A GSM modem is a specialized type of modem, which accepts a SIM card, and operates like a mobile phone; could also be a standard GSM mobile phone with the appropriate cable and software driver to connect to a serial port or USB port on computer. Any phone that supports the "extended AT command set" for sending/receiving SMS messages can be supported by the SMS/MMS Gateway.

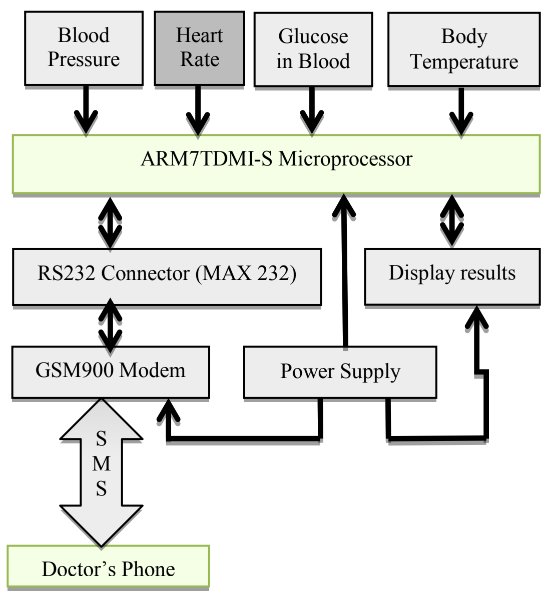


*Figure 7 :* Implementation of the complete system of patient monitoring system

This model proposed using SIMCOM SIM300 GSM module [1]. SIM 300 Modem [4] is built with tri Band GSM/GPRS engine, works on 900/ 1800/ 1900 MHz Frequency band can be set by AT commands. The Modem has RS232 interface which allows connecting microcontroller with MAX232. The MAX232 converter converts from RS232 voltage levels to TTL voltage levels and vice versa [1]. RS-232 connector circuit [4] is a serial port connector used to send the sensed parameters from patient to the modem, which then transmits all the parameters to the mobile phone of the physicist via SMS. To communicate and send results from GSM modem to desired mobile phone, Fig.7 presents necessary steps. Modem having internal TCP/IP stack suitable for SMS, Voice as well as DATA transfer application in M2M interface.

### c) *Algorithm for Coding*

Programming the ARM7 processor to implement the proposed model of patient monitor system needs the steps for as shown in Fig.8. The ARM7 microprocessor was chosen because of its faster speed. When the overall system is accumulated in a single chip such RISC microprocessor is necessary. The coding was done using C programming language and then converted to hex and loaded into the microprocessor.

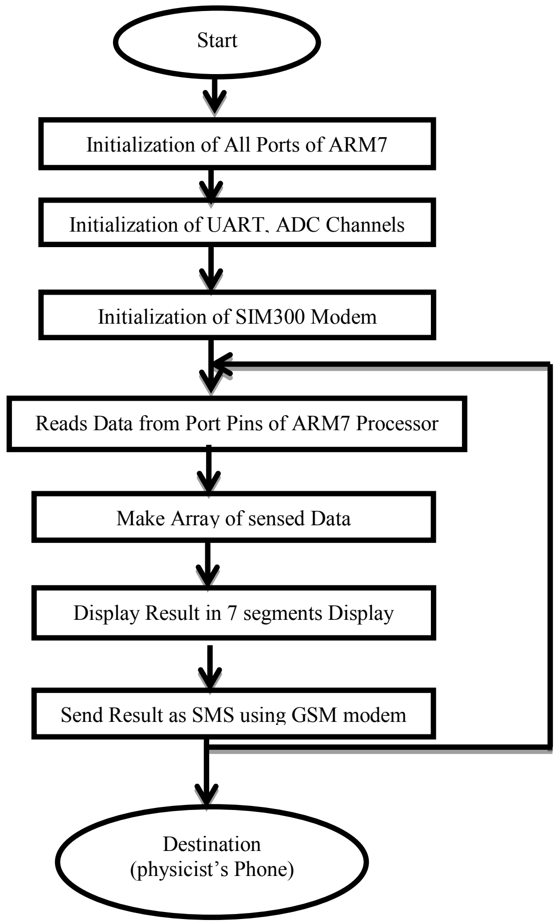


*Figure 8 :* Algorithm for coding

## V. Implementation & Future Improvements

This model will further modified to include Global Positioning System (GPS) tracking to make it more appropriate for hospital application. Sometimes age-old patient may fall in lift or washroom and serious hamper may occur. Incorporating GPS system the position of the patient will be monitored continuously and send via SMS. As internet facilities growing day by day online monitoring system will also tried to include. This will enable to send the observed data from the server computer to the monitoring computer via HTTP protocol which ameliorates the worldwide prescribtion for the patient. The measurement technique will also include some major signs like oxygen saturation, water level of saline bottle, pulse oximetry etc. so that this model can be used in both home healthcare and in hospital for general and ICU patient monitoring. Another modification will include visualizing the patient's condition using a webcam. In this model these facilities are avoided because of cost and to make it widespread applicable.

## VI. Conclusion

This model of patient monitoring system includes several subsystems which are reliable, cost effective, and accurate, user friendly and includes latest improvements. Using the system observing the data received experts can easily prescribe drug for that situation of patient via SMS. So implementation of these systems will be a great advancement in biomedical engineering and will provide healthcare facilities for the deprived mass people as well as for everyone.

## References Références Referencias

1. Dr. B. Ramamurthy, S.Bhargavi, Dr.R. ShashiKumar, "Development of a Low-Cost GSM SMS-Based Humidity Remote Monitoring and Control system for Industrial Applications," (IJACSA) International Journal of Advanced Computer Science and Applications,vol. 1, no. 4, 2010.
2. H. D. Lin, Y.S. Lee, and B.N. Chuang, "Using Dual-Antenna Nanosecond Pulse Near-field Sensing Technology for Non-contact and Continuous Blood Pressure Measurement," Proceedings of 34th Annual

International Conference of the IEEE EMBS, USA, 2012.
3. F. Ichihashi, and Y. Sankai, “Development of a Portable Vital Sensing System for Home Telemedicine,” Proceedings of the 29th Annual International Conference of the IEEE EMBS, 2007.
4. M. R. Patil, Prof. B. Hogade, “On Line Real Time Health Monitoring of ICU Patients using ARM7,” International Journal of Computer Science and Network (IJCSN) vol. 1, no. 3, 2012.
5. W. J. Li, Y. L. Luo, Y. S. Chang, Y. H. Lin, “A Wireless Blood Pressure Monitoring System for Personal Health Management,” Proceedings of 32nd Annual International Conference of the IEEE EMBS, 2010.
6. M. Park, H. Kang, Y. Huh, K. C. Kim, “Cuffless and Noninvasive Measurement of Systolic Blood Pressure, Diastolic Blood Pressure, Mean Arterial Pressure and Pulse Pressure using Radial Artery Tonometry Pressure Sensor with Concept of Korean Traditional Medicine,” Proceedings of the 29th Annual International Conference of the IEEE EMBS, 2007.
7. L. Y. Shyu, Y. L. Kao, W. Y. Tsai, W. Hu, “Development of a Cuffless Blood Pressure Measurement System,” Proceedings of 34th Annual International Conference of the IEEE EMBS, 2012.
8. W. V. Moer, L. Lauwers, D. Schoors, and K. Barbé, “Linearizing Oscillometric Blood-Pressure Measurements: (Non) Sense,” IEEE Transactions on Instrumentation and Measurement, vol. 60, no. 4, 2011.
9. S. Chen, M. Bolic, V.Z. Groza, H.R. Dajani, I. Batkin, S. Rajan, “Improvement of Oscillometric Blood Pressure Estimates Through Suppression of Breathing Effects,” IEEE, 2010.
10. B. K. P. Koh, P. Y. Kong, “Performance Study on ZigBee-Based Wireless Personal Area Networks for Real-Time Health Monitoring,” ETRI Journal, vol. 28, no. 4, 2006.
11. D. Parekh, “Designing Heart Rate, Blood Pressure and Body Temperature Sensors for Mobile On-Call System,” EE 4BI6 Electrical Engineering Biomedical Capstones, Department of Electrical and Computer Engineering, McMaster University, 2010.
12. P. I. Aaronson, J. Ward, and C. M. Weiner, Coronary Circulations: The Cardiovascular System at a Glance, Blackwell Publishing, 2003.
13. M. R. Neuman, “Vital Signs: Heart Rate”, IEEE PULSE, 2010.
14. R. Suarez, and C. Casillas, “Implementing a Glucometer and Blood Pressure Monitor Medical Devices,” Free-scale Semiconductor Document Number: AN4025, Application Note, 2010.
15. S. Y. Sim, W.K. Lee, H.J. Baek, K.S. Par, “A nonintrusive temperature measuring system for estimating deep body temperature in bed,” Proceedings of 34th Annual International Conference of the IEEE EMBS, 2012.
16. S. Chen, M. Bolic, V.Z. Groza, H.R. Dajani, I. Batkin, S. Rajan, “Extraction of Breathing Signal and Suppression of Its Effects in Oscillometric Blood Pressure Measurement,” IEEE Transactions on Instrumentation and Measurement, vol. 60, no. 5, 2011.

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