A LOW COST REAL TIME AMBULATORY BLOOD PRESSURE MONITORING & ALERT SYSTEM WITH GSM & GPS

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ABSTRACT

The monitoring of physiological parameters or Bio-vital signals has always been a challenging task to the scientific community. There are many such parameters which always requires constant monitoring like Blood pressure, Heart rate or pulse rate, ECG, Body temperature etc. Among them the blood pressure plays very crucial role as it is directly related to heart. Timely remedial medical assistance can save the heart patient from heart failure. Latest technologies are in use to monitor the blood pressure by either invasive or non-invasive methods. Development of advanced microcontrollers, wireless communications techniques, GSM & GPS technologies, high sensitive wearable sensors have led the monitoring of blood pressure more accurate, thus helps the patients to move around without restriction or otherwise patients are confined to the hospital environment. This paper proposes a simple 51 architecture based low cost real time ambulatory blood pressure (systolic & diastolic) monitoring system that uses non-invasive method. For clinical trials, the designed system was tested in the hospital for different age & weight people. Finally, we compared these results with readings taken by Doctor with traditional instrument like sphygmomanometer & stethoscope. The system is backed with GSM & GPS technologies. The GSM architecture is for bio-vital information transformation through SMS and GPS is for location awareness. Especially the developed system is aimed at aged or elderly people, as the movement of these people is restricted because of age factor. Certainly, the combination of these technologies in a single module fulfils the requirements of delivering critical information to concerned people.

KEYWORDS: Non-Invasive Blood Pressure, Sphygmomanometer, Systolic, Diastolic, GSM and GPS

Blood pressure (BP): It is the pressure exerted by the circulation of blood upon the walls of the blood vessels and is one of the major vital signs. Usually it is also called as arterial pressure of the systemic circulation, and is measured at a person's upper arm. It is expressed in terms of the systolic pressure over diastolic pressure and is measured in millimeters of mercury (mm Hg). Normally at resting position, the blood pressure for an adult is approximately 120/80 mm Hg. The Blood pressure varies depending on the environment, daily activity, and disease states, and it is controlled by the nervous and endocrine systems. Pathologically low blood pressure is called hypotension and high blood pressure is called hypertension.

Classification of Blood Pressure: The following table shows, the classification of Blood pressure in adults.

Blood Pressure Measurement: There are two important methods to measure the blood pressure. Invasive and Non-Invasive method. The invasive method involves surgical technique in which pressure sensors are inserted in artery which measures continuous blood pressure and there is high risk of infection. And the other method is Non-invasive most commonly called auscultator method which requires an operator besides the patient. It is based on contemporary use of a sphygmomanometer and a stethoscope. This sphygmomanometer has cuff, which inflates & deflates with a pressure sensor fixed on the arm with respect to brachial artery. The stethoscope is used to hear the arterial sound which is also known as Korotkoff sound during deflation of cuff slowly which is used to measure the systolic and diastolic pressure. This method offers some difficulty in signal analysis due to variation while hearing the Korotkoff sound.
In this paper we have proposed a system to perform a non-invasive measurement of the blood pressure based on oscillometric method by using OMRON make digital NIBP model HEM-7111 which also uses a wearable cuff sensor. The system is able to evaluate both systolic and diastolic pressures. The proposed system is rigorously tested in the hospital for clinical trials. Finally the results are compared.

RELATED WORK

The outcome of the literature survey is that, many researchers have employed very latest technologies for measurement of blood pressure with invasive or non-invasive method. Also employed wireless devices/sensors for this purpose. (Hango Shivaraman and Sridhar Pooja, 2014) describes a non-invasive blood pressure, ECG, PPG & PTT measurement system using android smart-phone with cuff-less technique. (Figueredo M V M and Dias J.S, 2004) suggests mobile telemedicine systems are now a day’s becoming more popular, in which wireless sensors collects the data and sends through RS232 to a server with internet facility. (Pandian P.S et.al, 2008) reports another aspect of collection of bio-signals is the use of wireless sensor Network, where wearable sensors are fixed on to the patient body which transmits the signals. (Labat Maxime et.al, 2012) adapted wearable blood pressure sensor for collecting the vital data and used electrocardiogram (ECG) & Photopletysmograph (PPG) as basis of blood pressure calculation. (Savaliya V. Piyush et.al, 2015) suggested use of short distance Bluetooth communication technique for measurement of bio-vitals based on FPGA approach. (Vinaykumar M and Sagar M, 2014) reports the use of ARM controller with GSM communication technique for collection & transmission of physiological parameters wirelessly on a cell phone. (Vasudevan. K Sriram et.al, 2013) verifies the adaptability of Zigbee communication techniques which collects & transmits the bio signals to a computer, so that doctor can monitor the patient within the hospital environment. (M. Priya et.al, 2013) has attempted to develop PIC based wireless ICU monitoring system that uses the Zigbee communication protocol. Wireless Bio-vital sensors collect the data and Zig-bee transmits these data to a PC through RS232 due to which doctor can monitor vital information on his PC remotely. (Aminin Media et.al, 2013) also proposes use of wireless sensors to collect the bio-signal information from multiple patients’ body. A coordinator node receives these data and sends to a base station. Any abnormalities can alert the doctor through SMS/E-mail. (Shahriyar Rifat et.al, 2009) has engineered intelligent mobile health monitoring system (IMHMS) by using a combination of variety’s of technologies such as wearable body sensor network (WBSN), Patients personal Home Server (PPHS) and an Intelligent medical server (IMS) for monitoring various physiological parameters. (S.Choy Janny et.al, 2014) has reported a fully implantable telemetry system to measure hemo-dynamic in swine heart failure with the help of a remotely positioned radio frequency link. (Abdullah Amna et.al, 2015) has suggested architecture of development of a real time wireless health monitoring application using ZXg.bee communication technology with labview software as front end program for recording physiological parameters. (F.Sudhindra et.al, 2014) Blood pressure levels either systolic or diastolic can not be varied on the living subject (human being), Looking at this point authors have suggested a GSM & GPS enabled simulated blood pressure monitoring system in which the values of systolic & diastolic pressures varied with the help of electronic circuit. This paper proposes design and development of a simple low cost 51 architecture microcontroller based embedded system that monitors ambulatory blood pressure, The system also uses GSM & GPS network to transmit the vital information & location awareness. It also compares the values obtained from the developed system under clinical trials with the values taken by doctor with traditional devices.

SYSTEM OUTLINE

Here, we have proposed a simple 51 architecture family of microcontroller based Ambulatory Blood Pressure Monitoring (ABPM) system. The system uses Non-invasive method for blood pressure measurement for which Omron make NIBP model HEM-7111 is used. The developed system is called Ambulatory because at specific interval of time (2 min) it takes readings for blood pressure as this method is very much essential for cardiac patients wherein every specified interval of time it is necessary to monitor the blood pressure. The system makes use of GSM architecture/network & its ability for mobile communication to transmit the bio-vital signal information to an authorized person’s cell phone. The system has GPS technology for identification of location, by taking Longitudinal & Latitudinal values of the geographical location. The GPS receiver sends information in the form of SMS. The system has ability to responds to SMS messages sent by the caretaker/doctor, verifies the authenticity and then sends a reply to SMS with which one can know the status of physiological parameter of concern person.

METHODS AND MATERIALS

Fig.1 shows the functional block diagram of the proposed systems. The hardware is built on 51-architecture. The components are OMRON make NIBP model HEM-7111,
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LCD display unit, GPS receiver, GSM modem, ADC, physiological parameter setting knobs etc. Many of the components are common for a normal embedded system. We will discuss all the components in brief in the following sections.

![Functional Block Diagram of the System](image)

**Figure 1: Functional Block Diagram of the System**

- 89c052- Microcontroller.
- Dual Band GSM Modem.
- GPS Receiver
- OMRON NIBP-HEM-7111
- Relay & Driver circuit
- Analog to Digital Converter (ADC)
- LCD Display unit.
- Physiological parameter settings Knobs
- Emergency Switches

**Embedded microcontroller:** The Atmel’s 89C52 microcontroller is used for this work 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 consists of a full duplex serial UART and internal timer/counter. It is an ideal choice for compact embedded system design for such applications with low cost.

**Dual band GSM modem:** GSM that is Global Standards for Mobile Communication Systems. It is a wireless MODEM which can send & receive data through the GSM network. It needs a SIM card and connectivity to the GSM network. It has 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 essential.

**GPS receiver:** GPS is a network of satellites that constantly transmit coded information, which makes it possible to accurately identify locations on earth by measuring distance from the satellites. Generally, most GPS receivers support the NMEA (National Marine Electronics Association) GPS Receiver is available as interface modules from various manufacturers. Most GPS are capable of sending information through a simple serial link. The GPS Receiver proposed to be used in this system will receive the coordinates needed from the GPS satellites. It will send the information to the microcontroller. Because of its compact size and low power consumption, it can be embedded into many portable devices. It has the capability to refresh its data once every second and therefore will be continuously updating the coordinate values for the microcontroller as the person changes location.

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

**Short Message Service (SMS):** Short Message Service (SMS) is very 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. Hence, many of wireless embedded system uses SMS communication method for remote monitoring and controlling.

**OMRON NIBP module (HEM7111):** - Non Invasive Blood Pressure NIBP is measured using OMRON NIBP module. It contains a pneumatic pressure pump and an external inflating rubber cuff and a strain gauge based pressure measurement system. After receiving command from the microcontroller, this module gradually inflates the cuff and senses the pressure in the cuff. After the pressure goes just above the systolic pressure, it records this value and after that it starts to deflate the cuff. After the pressure goes just bellow the diastolic pressure, it records this value also. In the mean time it also counts the heart rate by sensing the pulsations in the pressure value. The microcontroller sends commands and extracts the values of systolic pressure and diastolic pressure from this module through the serial RS-232 port link as shown in fig.2
Relay & Relay driver circuit: This relay is used to turn ON the NIBP unit. A time loop is created in the program so as to ON & OFF the NIBP units within specified time interval say for example 2 min. For every 2 min the NIBP unit automatically turns ON & OFF and takes afresh readings. This method is called ambulatory blood pressure monitoring method. Highly essential for risky cardiac patients.

Analog to digital converter (ADC): The ADC is used to convert the analog signal into a binary number. When any analog signal is applied at its inputs, it start the conversion process, an ADC converts the input signal into a proportional binary value, by taking some time. When it finishes conversion and is ready with the digital data, it indicates with an end of conversion signal. The controller can now read the digital data from ADC. An 8-bit, successive approximation type ADC 0809 is used.

LCD display Unit: The system uses 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.

Physiological parameter settings Knobs: It is a facility given to the doctor to set the physiological parameters of a particular patient (here it is blood pressure), as the doctor himself knows these values very accurately if he monitors ones or twice. Any abnormalities in the physiological parameters from the set values will be reported immediately through SMS.

Emergency Switches: It is a simple push button switch. In case of critical condition of the patient, if simply pressed this emergency switch, the system becomes active, takes the readings and sends the message to doctor with afresh bio-vital information.

SOFTWARE IMPLEMENTATION

As the designed & developed systems are dedicated embedded system based on 51 architecture, software was written in assembly language & stored in the memory of the controller. Before switching on the power supply, NIBP module must be connected to the patient. When power is switched ON the system comes to ON condition from RESET position then the program is executed and controller freshly takes all the readings for local display on LCD with and also sends SMS to doctor.

EXPERIMENTAL RESULTS & DISCUSSION

The developed system was taken to the hospital for clinical trials. Firstly we have asked the Casualty Medical Officer (CMO) of the hospital to take the blood pressure readings for 10 different age & sex patients with their traditional BP apparatus with stethoscope. We have recorded the systolic and diastolic i.e high & low blood pressure respectively. Then we have connected the developed instrument of to the same 10 patients and obtained the readings. The results are shown in table 1.
Finally, we have compared these readings i.e. readings taken by the CMO & the readings taken with the help of developed instrument. After having consultation & discussion with the CMO, we came to know that, there is always 10 points variation in the readings with the analog & digital signals which is normally admissible. The table shows nearly 10 points variations. The photograph of the experimental setup is shown in fig.3 & in the event of abnormality, the system sent message on to the doctor’s cell phone shown in fig.4. The photo-snap of the experimental set up while it was on clinical trials in the hospital is shown in fig.5. The system has expressed its ability with GSM network for blood pressure monitoring and notification in case of medical emergencies. The location awareness is achieved through GPS technique. The system gets the geographical locations from GPS receiver to calculate the latitude and longitude of the place/location and prepares a concise SMS and sends the information through the GSM modem to the mobile phone of the doctors as in fig.4

From the above discussions it is clear that the system is automatic, wireless, portable and practically we can make use of the developed system for monitoring the patient conditions.

Table 1: Comparison of Physiological Parameters

<table>
<thead>
<tr>
<th>Subject Identify</th>
<th>Weight In (kg)</th>
<th>Blood Pressure in mm Hg Readings taken by Doctor with traditional instrument</th>
<th>Blood Pressure Readings taken by Developed Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sys (high)</td>
<td>Dys (low)</td>
</tr>
<tr>
<td>Patient-1</td>
<td>68</td>
<td>140</td>
<td>80</td>
</tr>
<tr>
<td>Patient-2</td>
<td>47</td>
<td>100</td>
<td>60</td>
</tr>
<tr>
<td>Patient-3</td>
<td>55</td>
<td>100</td>
<td>60</td>
</tr>
<tr>
<td>Patient-4</td>
<td>72</td>
<td>136</td>
<td>94</td>
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<tr>
<td>Patient-5</td>
<td>67</td>
<td>110</td>
<td>70</td>
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<tr>
<td>Patient-10</td>
<td>65</td>
<td>108</td>
<td>82</td>
</tr>
</tbody>
</table>
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The details of this SMS are as follows:

- Systolic Blood pressure (High) = 142
- Diastolic Blood Pressure (Low) = 099

This Systolic & Diastolic Blood Pressure reading refers to patient number 4. The GPS locations are:

- LAT=1718.8014.N (Latitude North)
- LON=07652.6666.E (Longitude East)

CONCLUSIONS

The design, development & implementation of this research work is done to sense, send, display and store the physiological parameter such as blood pressure. The system is simple, low cost and portable. The final aim of the work is to reduce the cost of hospitalization & assistance and to increase patient's quality of life. The system has functioned satisfactorily and can be used by elderly people or people suffering from variety of medical ailments & thus to improve medical care quality of adult people.

REFERENCES


