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A Non Invasive Heart Rate and Blood Pressure Remote Monitoring System

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***Abstract*—**Health monitoring systems have become an important research field today. Research on health monitoring were developed for many applications such as in home care units, emergency monitoring systems etc. This paper proposes the design of a non invasive wireless heart rate and blood pressure remote monitoring system based on an embedded board and Bluetooth wireless technology. The real time biomedical signal is sensed and measured using an optical measurement circuit based on Photoplethysmography technique. Blood pressure and heart rate readings are calculated on the basis of the developed algorithm and are displayed on the LCD screen. Moreover these numerical values of heart rate, systolic and diastolic pressure can be transmitted to any bluetooth enabled computer or smart phone via Bluetooth wireless technology.

Keywords- *blood pressure ; heart rate ; systolic ; diastolic ; plethysmography; bluetooth;*

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I. INTRODUCTION

Health monitoring is an important concern to be addressed in a developing country like India. It is a growing concern among people to have a check on their health condition themselves. This issue has to be addressed with many continuous health monitoring devices which have to be portable, economical, reliable and easy to operate even by a normal individual. This gives a chance to improve the health care facilities in many rural places where advanced equipment is not an option.

There has been a drastic increase in the health care costs in the last decade. Elders have to make frequent visits to their doctor to get their vital health parameters measured. The objective of this paper is to design and implement a cheap, reliable, low powered, non-intrusive, and accurate system that can be used on a regular basis and monitors the vital signs and displays the output on an lcd screen. This data is also easily accessible by the physician through wireless network. This paper specifically deals with the data acquisition and signal conditioning of two vital parameters: heart rate and blood pressure.

II. BACKGROUND

Blood pressure (BP) is defined as the measurement of the force applied on the walls of artery vessels as heart pumps blood through the body. Blood pressure can be of two types : systolic Blood pressures (SBP) and diastolic Blood pressure (DBP). Systolic blood pressure is the maximum pressure on the walls of the arteries which happens during the time when the ventricles are contracting while diastolic is the minimum pressure in the arteries, which happens near the end of the cardiac cycle when the ventricles are completely filled with blood. Typically, measured values for a healthy, resting adult are 115 millimeters of mercury (mmHg) systolic and 75 mmHg diastolic [1][9]. Systolic and diastolic blood pressure measurements are not always static and does tend to change during the day. They also change in response to stress, drugs, nutrition, illness and exercise [1].

The blood pressure measurements are of great importance because it is used for detection of hypertension. Moreover blood pressure measurements are important for particular disease patients, such as hemodialysis patients. Hence, in the daily life, proper blood pressure measurement and management is very useful for handling health situation and plays a preventive function.

While Heart rate indicates the soundness of the heart and helps in assessing the condition of cardiovascular system [2]. A heart rate monitor is defined as a device that takes a sample of heartbeats and computes the Beats per Minute (bpm) so that the information can be used to track the proper heart condition. There are basically two methods to develop heart rate monitors- electrical and optical methods. The former that is the electrical method has an average error of 1 percent while the latter has an accuracy rating of 15 percent.

Normally the average resting human heart rate is about 70 bpm for adult males and 75 bpm for adult females. Heart rate varies greatly between individuals based on their age, fitness and genetics. Heart rate can be directly measured by measuring one's pulse. Pulse measurement can be done by using specialized medical devices, or by merely pressing one's fingers against an artery. It is generally accepted that listening to heartbeats using a stethoscope known as auscultation, is a more exact or accurate method to measure the heart rate [2]. There are many other methods to measure heart rates like Phonocardiogram (PCG), ECG, blood pressure wave form [2] and pulse meters [2] but these methods are clinical and expensive. There are also many other cost-effective methods that are implemented with sensors as proposed in [2] and but they are susceptible to noise and movement of subject and artery.

Hence Continuous measurement of Blood pressure and heart rate for home care requires an accurate and inexpensive method that is completely independent from patient movement and does not require continuous care by a practitioner. These requirements can be found in the proposed monitoring system

which will be designed using photoelectric plethysmography (PPG) technique.

Photoelectric Plethysmography is a non-invasive method used to measure relative changes in blood volume in the tissues. It utilizes the reflectance sensor that contains an infrared light source. The light source illuminates a part of the tissue (fingertip, toe, ear lobe, etc.) and a photo-detector receives the returning light. The waveform obtained from this technique represents the pulse waveform which can be used to measure blood pressure and heart rate.

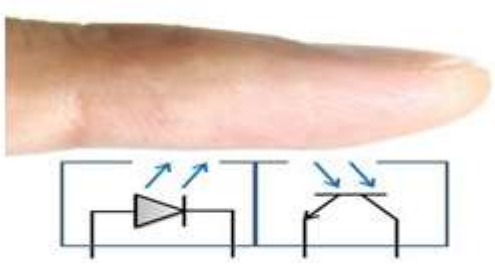

Figure 1: PPG concept

PPG concept is shown in figure 1 where an Infra-red (IR) sensor is used as the source and a phototransistor is used as the detector. The PPG sensor operates in reflection ('adjacent') mode where the source and the detector are placed side by side.

III. PROPOSED SYSTEM DESIGN

The block diagram of the proposed monitoring system mainly consists of three units: the sensing and measurement unit, Signal conditioning unit, Embedded board based processing and transmission unit. The block diagram is shown in fig. 2

A. Sensing And Measurement Unit

The detection of the blood pressure signal is based on using the optical measurement technique called photoelectric plethysmography (PPG). The PPG technique basically utilizes two components: a light source to illuminates a part of tissue of the body and a photo detector to receive the returning light. Transparency of living tissue to light makes it possible for some amount of light from the source to pass through the tissue to the photodetector. However, some part of the light get absorbed by the muscle, blood, bone and skin in the tissue. The volume of the blood in the vessel varies while the volume of blood present in other parts remains constant. Therefore the light absorption as well as the amount of light reflected back to the photodetector is varied only by the change in blood volume. The electrical resistivity of the photo-detector varies depending on the amount of light falling on it. This change of resistivity results in the change of electrical current flowing through the detector which is converted into the PPG signal.

In this system an optical sensor is used, which consists of an infra-red emitting diode as the transmitter and a phototransistor as the receiver. The PPG sensor operates in reflection ('adjacent') mode where the source and the detector are placed side by side.

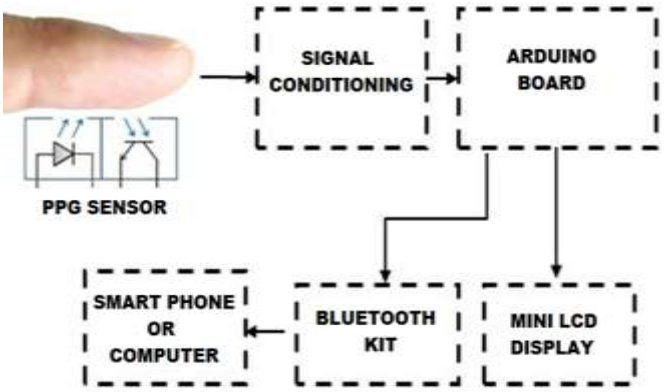

Figure 2: Block Diagram

B. Signal Conditioning Unit

Signal conditioning unit was designed and simulated using Multisim software. After the sensor detects the changes in the blood volume a low frequency and low magnitude biopotential signal is received by the phototransistor. As the detected PPG signal is weak, it must undergo some signal conditioning (e.g. amplifying and filtering) so that it can be used for further processing.

Since the output voltage of the photodetector has a large amount of dc component which requires a filter to suppress out the dc component. An excellent filter choice will be the use of an active band pass filter because its first cut off frequency can be used to remove the dc component while its second cutoff frequency can be used to remove unwanted or undesired high frequency noise components present in the signal like power line interference (50 Hz). In addition, the filter is also designed with a very high gain for amplifying the signal. Two stage band pass filter is used and each stage has different gain. Band pass filter is shown in figure 3.

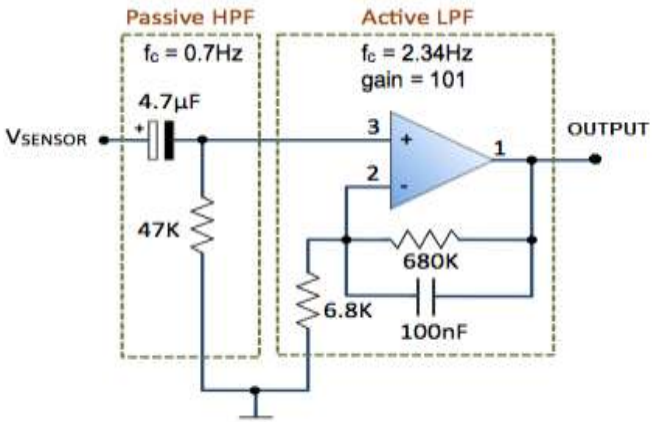

Figure 3: Band Pass Filter

The output of the sensor passes through the RC high-pass filter (HPF) to remove the DC component before passes through the active low-pass filter (LPF) which is an Op-Amp circuit to amplify the signal and to remove the high frequency noise. The cutoff frequency for the HPF is 0.7Hz and the cut-off frequency for the LPF is 2.34Hz with 101gain respectively.

The output of the first stage of signal conditioning passes through a second signal conditioning stage containing the same HPF and LPF combined for further filtering and

amplification. Thus, the total voltage gain for the cascaded stage is 10201. These two stages of signal conditioning converts the input PPG signal to near TTL pulses and they are synchronized with the heartbeat.

C. Signal Processing And Transmission Unit

The output signal from the signal conditioning stage is fed into an embedded board where it is processed (sampled and quantized). The Arduino UNO board is used in this system which has a built-in ADC. The embedded board then finds out the smallest (represents diastolic pressure) and the largest (represents systolic pressure) value from the output voltage using the program written in Arduino software. The system then displays the measured blood pressure and heart rate information on the LCD screen and also transmits these values through Bluetooth to any Bluetooth enabled device. Implemented Blood pressure and Heart rate monitoring system is shown in figure 4.

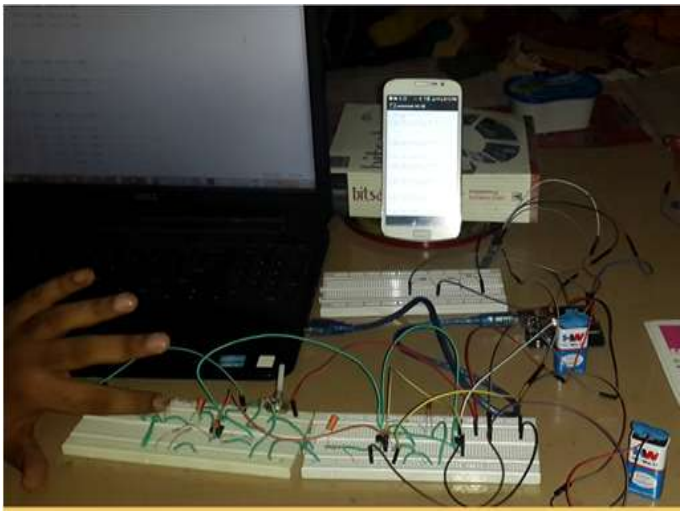

Figure 4: Implemented Blood Pressure and Heart Rate Monitoring System

IV. RESULTS AND DISCUSSION

This section discusses the implementation and simulation results of the proposed system. The proposed system is designed to overcome the issues of existing health monitoring systems. The system is designed in such a way that it is capable of monitoring various parameters related to health conditions and also capable of transmitting corresponding readings to any Bluetooth enabled device via Bluetooth wireless technology. The resulting system is low cost, low power, non-invasive, easy to use and also provides real time continuous monitoring.

Photoelectric Plethysmography also known as PPG is main theme of the blood pressure and heart rate monitoring system.

PPG is a non-invasive method used to measure relative changes in pulse blood volume in the tissues.

The proposed system mainly consists of three stages: the sensing and measurement stage, signal amplification stage, Embedded board based processing and transmission stage. Each of these stages are successfully designed and simulated and finally combined to develop our proposed blood pressure and heart rate monitoring system. Output blood pressure and heart rate readings obtained from our proposed system are displayed in figure 5.

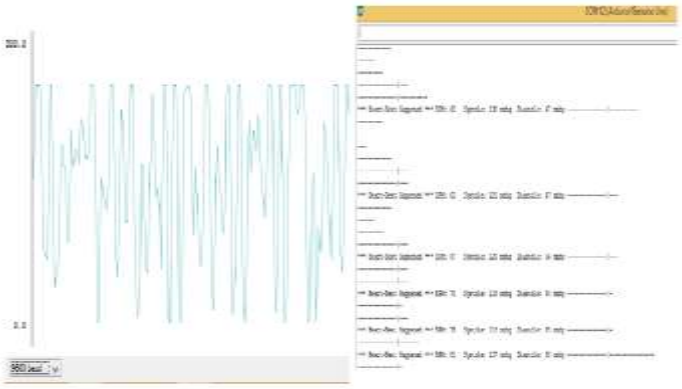

Figure 5: Output Signals and Readings Displayed

Moreover apart from designing and developing the proposed system using Arduino board and PPG sensor I have also succeeded in providing wireless capability using Bluetooth to the developed system. By providing the wireless capability to the developed system, it can now transmit the measured readings to any Bluetooth enabled device though Bluetooth wireless technology. Also this system provides users an easy-to-use interface and simple Blood pressure and heart rate management environment. Apart from these the Bluetooth interface also provides a convenient and low-power consumption method for data transmission for our developed system.

V. CONCLUSION

The objective of this paper was to build a low power, low cost, reliable, non-intrusive, and non-invasive health monitoring system that would accurately measure two of the important vital signs namely heart rate and blood pressure. A reliable and continuous heart rate and blood pressure monitoring system targeted towards older individuals has been successfully built. The resulting system is also low cost, low power, accurate, non invasive, and provides real time monitoring. Moreover this system provides users an easy-to-use interface and simple Blood pressure and heart rate management environment. Also the Bluetooth interface provides a convenient and low-power consumption method for data transmission.

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