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Non-Invasive Blood Pressure Monitoring Instrument By Using Microcontroller

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Abstract
This paper presents design and development of a Non-invasive serial blood pressure data acquisition instrumentfor remote monitoring based Micro-controller and serial transmission kit. The real-time blood pressure biomedical signal is measured using an optical measurement circuit based Plethysmography technique (PPG) continuously for a long period of time. The detected measured signal amplified using an operational amplifier circuit and interfaced with the Microcontroller. Blood pressure readings with help of developed algorithm has been calculated and transmitted via serial kit to the stationary computer. Numerical reading values of systolic and diastolic blood pressure remotely recorded and displayed with help of LCD as well stationary computer. Furthermore, the obtained results were compared with existing devices data like a Sphygmomanometer to verify the accuracy of the developed Instrument..
Keywords:- Noninvassive measurement; continuous blood pressure; monitoring system; serial.

1. INTRODUCTION

Blood pressure (BP) is a measurement of the force applied on continuous long-term monitoring applications. Continuous the walls of artery vessels as heart pumps blood through the body. measurement of BP for homecare requires an accurate and Moreover, blood pressure measurement is known as one of the vital inexpensive method that is independent from patient movement and signs and is widely used to monitor the physiological condition of does not require continuous care by a practitioner. These human beings along with other vital signs such as heart rate, requirements can be found in this monitoring system which will be breathing rate, oxygen saturation and temperature [1]. Blood designed using photoelectric plethysmography (PPG) technique. pressure can be seen as two variation systolic Blood pressures (SBP) PPG is a simple non-invasive method used to measure relative and diastolic Blood pressure (DBP), and systolic is the peak or the changes in pulse blood volume in the tissues. It utilizes the use of maximum pressure on the walls of the arteries which happens when reflectance sensor that contains an infrared light source. The light the ventricles of the heart are contacting. While, diastolic is the source illuminates a part of the tissue (fingertip, toe, ear lope, etc.) minimal pressure in the arteries, which happens near the end of the and a photo-detector receives the returning light. The waveform cardiac cycle when the ventricles are filled with blood. Typically, obtained from this technique represents the blood volume pulse measured values for a healthy, resting adult are 115 millimeters of which can be used to measure blood pressure. PPG concept is shown mercury (mmHg) (15 kilopascals [kPa]) systolic and 75 mmHg (10 in fig. 1 where an Infra-red (IR) sensor is used as the source and a kPa) diastolic [2]. Systolic and diastolic blood pressure phototransistor is used as the detector. The sensor operates in measurements are not always static and Blood pressure does tend to reflection ('adjacent') mode where the source and the detector are change during the day. They also change in response to stress place side by side. More to the point, a developed technique based attrition, drugs, and illness and exercise [3]. The measurements of BP are of a great importance because it is used for detection of hypertension (high blood pressure). Hypertension is a continuous, consistent, and independent risk factor for developing cardiovascular disease. Hypotension can cause the blood supply to the brain, heart and other tissues to be too low, and hypertension is strongly correlated with higher risk for cerebral stroke and heart infarct [4]. Blood pressure measurement is also important for particular disease patients, such as hemodialysis patients. Hence, in the daily life, blood pressure measurement and management is very useful for handling

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health situation and plays a preventive function. Most non-invasive blood pressure monitors are based on either the auscultation or the oscillometric method [5]. Although both methods are generally accepted and widely used but they severely restrain patients' mobility, they require uncomfortable on a noninvasive continuous blood pressure measurement using

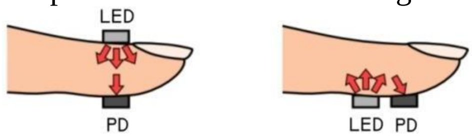

Fig-1 Photoplethysmographic Technique

volume oscillometric method and photoplethysmograph technique has been investigated [6], and the study uses high intensity LED and a LDR (Light Dependent Resistor) and placed them at the edge of a finger. The concept is that the resistance of the LDR changes according to the light intensity received by the LDR. The change in resistance is proportional to the change of blood volume and as well as blood pressure in the finger. The result showed the systolic and diastolic blood pressure on a mini LCD. In addition, a non-invasive blood pressure monitor was developed using photoplethysmograph method. Authors used infrared transmitter and receiver to estimate blood pressure in the fingertip. Authors were able to measure blood pressure and concluded that the results are in agreement with the standard blood pressure measurements [7]. On the other hand, a serial digital measurement system was implemented and developed. In approach, piezoresistive transducer was usedas the sensor and the device makes use of a microcontroller and a Sallen-Key active. The system transmits the collected data to a remote computer through a serial device [8]. Moreover, blood pressure measuring system at the wrist based on the volume-compensation method has been developed [9]. The authors used a method called volume- compensation in which cuff pressure (Pc) is gradually increased, and then the unloaded vascular volume (V0) is determined from the mean level of the DC component of the photo plethysmography (PG) signal (PGdc) at point of maximum amplitude of the pulsation signal of PG (PGac) [9].

1. METHOD AND MATERIALS

The block diagram of the developed system is shown in fig. 3. The system mainly consists of three stages: the sensing measurement circuit, signal amplification circuit, microcontroller and transmissionunit.

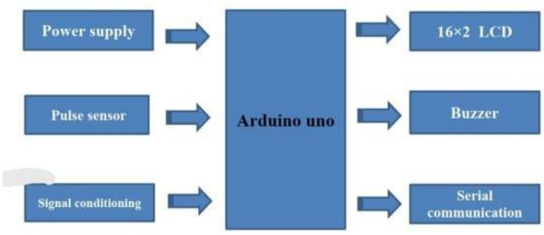

FIG-2 – Block Diagram

A. Sensing stage-

The detection of the blood pressure signal is based on usingoptical measurement technique called photoelectricplethysmography (PPG). This technique has the ability to detect the volume of blood pressures in the arteries. The PPGbasic form utilizes two components: a light source toilluminates a part of the tissue (e.g. fingertip) and a photodetector to receive the light. Transparency of living tissue tolight makes it possible for some part of the light from thesource to pass through the tissue to the photo-detector.However, some part of the light is absorbed by the blood, bone,muscle and skin in the tissue. The volume of the blood in thevessel varies while the volume of other part remains constant.Therefore the light absorption is varied only by the change ofvolume of blood (increases or decreases) and the returninglight to the photo-detector changes according to the change

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ofblood volume. The electrical resistivity of the photo-detectorchanges depending on the amount of light falling on it. Thischange of resistivity results is the change of electrical currentflowing in the detector which is converted into PPG signal. Inthis system optical sensor is used where it consists of infra-red emitting diode as the transmitter and a photodiode as the receiver. The sensor operates in reflection (‘adjacent’) mode where the source and the detector are placed side by side.

B. Signal conditioning stage-

After the sensor detected the changes in the volume of blood pressures, a low frequency and low magnitude biopotential signal is received by the photodiode. As the detected PPG signal is so 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 photo-detector has alarge amount of dc component which requires a filter to suppress out the dc component. A good filter choice will be the

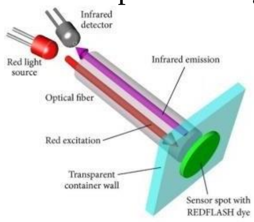

FIG 3 – Optical sensor

use of an active bandpass filter because its first cut off frequency can be used to remove direct current (DC) and its second cutoff frequency can be used to remove unwanted high frequency components in the signal like power line interference (50 Hz). In addition, the filter is also used with a very high gain for amplifying the signal.Two stage bandpass filter are used and each stage has different gain. The design of For first stage the gain is calculated using:

$$A1 = 1 + \frac{R1}{R5} = 1 + \frac{1M}{8.2k} = 122.95 \qquad (1)$$

Normally the frequency of An average person’s heart rate isbetween 60 and 80 bpm (1Hz to 1.2Hz) [1], thus the bandwidthof the filter will be set between 0.2 Hz to 2.5 Hz so that thePPG signal frequency is saved and the noises are cancelled out.

The cut off frequencies are calculated using for low frequency.

$$f_c = \frac{1}{2\pi R4c3} = \frac{1}{2\pi(68k)(10\mu)} = 0.2\text{Hz} \qquad (2)$$

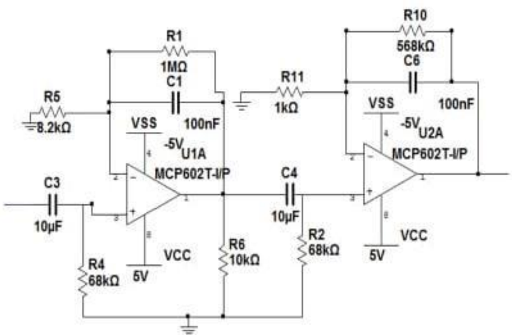

Fig. 4. Multisim simulation of double stage bandpassfilter.

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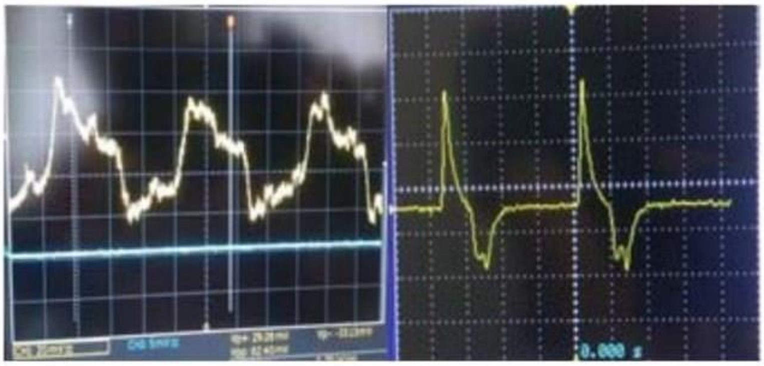

Fig. 5. Input and output waveform of amplifier in Multisim.

$$f_c = \frac{1}{2\pi R1c1} = \frac{1}{2\pi(1M)(100n)} = 2.5\text{Hz} \qquad (3)$$

For second stage (from fig. 3.3), the gain is calculated using:

$$A2 = 1 + \frac{R10}{R11} = 1 + \frac{560k}{1k} = 661 \qquad (4)$$

The cut off frequencies are calculated using for low frequency

$$f_c = \frac{1}{2\pi R4c3} = \frac{1}{2\pi(68k)(10\mu)} = 0.2\text{Hz} \qquad (5)$$

For high frequency

$$f_c = \frac{1}{2\pi R1c1} = \frac{1}{2\pi(568k)(100n)} = 2.8\text{Hz} \qquad (6)$$

The total gain of the system is calculated by multiplying the gainof the first stage with the gain of second stage as shown:

Total Gain is (A1*A2) = 68292

C. Microcontroller stage-

The output of the signal conditioning stage is fed into a microcontroller where it is processed (sampling and quantizing). The Atmega32 microcontroller is used in this system where it has a built-in ADC. The microcontroller finds out the smallest (represents DP) and the largest (represents SP) value form the output voltage using a program written in ardunio software. The microcontrollerthen displays the measured blood pressure information in mini LCD and transmits them through a serial device to any stationary enabled computer device. The program flowchart is shown in fig. 7 where the microcontroller is initialized and then set to read the analog signal form pin A0. Timer interrupt 2 is used here so that we can keep track if there are changes in the signal. The microcontroller then finds the highest peak of the signal and the lowest peak of the signal and then displays them as systolic and diastolic readings respectively in the LCD and Parallel serial terminal software via serial transmissionkit.

2. RESULT AND DISCUSSION

The input and output waveform of the amplifier circuit

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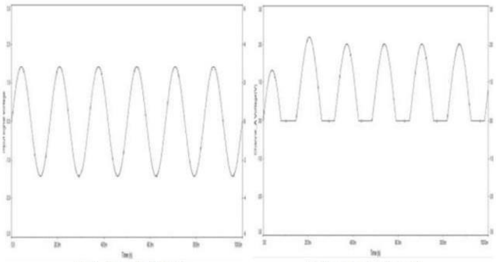

(a). input signal (b) output signal

Fig. 6. Output of measurement circuit (left) and output of analogsignal (right).

After simulation, the analog circuit was tested in the lab using oscilloscope. The oscillographic representation of the blood pressure measurement circuit and the analog signal (signal conditioning) are shown in Fig.10 ,which were practically observed. The output of the measurement circuit (on the left) was observed before amplifying. While, the output of the signal conditioning or analog circuit (on the right) was observed after using the two stage bandpass filter with amplifier.

3. OUTPUT

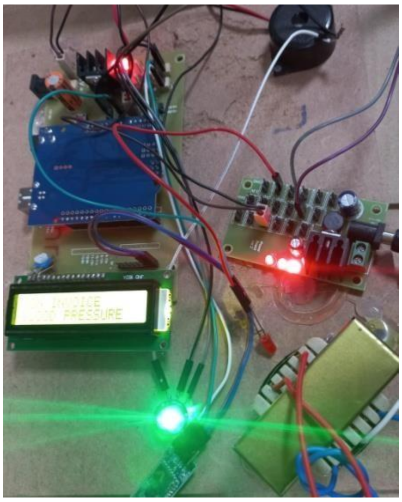

Fig-7- Working of Non-invasive Blood PressureMonitoring Instrument by using Microcontroller.

FIG 8 – BP output

FIG 9- Output of High BP

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4. Advantages

- It is simple, reliable, and inexpensive.
- It can easily be integrated into wearable healthcare devices for various human vitals.
- PPG-based wearable devices do not require special training or guidance.

5. CONCLUSION

In this paper, we developed Noninvasive serial Remote Monitoring Blood Pressure Measurement Instrument based Microcontroller and using photoplethysmography technique. The blood pressure was measured continuously for a long period of time with help of developed algorithm the small embedded system and displayed the systolic and diastolic blood pressure on a mini LCD. The results were further compared with existing devices data like sphygmomanometer to verify the accuracy of the developed system. Moreover, the developed system can transmit the measured blood pressure values to any serial enabled device though serial technology. This system provides users an easy-to-use interface and simple BP management environment. The serial interface provides a convenient and low-power consumption method for data transmission..

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Future Work

This work can to monitor other vital parameters such as ECG, heart rate, body temperature etc. ESP system can be used to include the Wi-Fi facility and store the data onto database..

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