

# **Non Invasive Blood Pressure Monitoring System**

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**ABSTRACT:** In this paper a non invasive system that continuously acquires the real time blood pressure signals is discussed. The signals from pressure transducer are very weak, hence an MPM (Multi Parameter Monitoring) module that performs the amplification and filtering of blood pressure signal is designed. This MPM can be used for monitoring various other vital parameters. Using MPM the unwanted frequency components are filtered off and amplified hence large dynamic range of data is available for processing. Blood pressure measurement using the traditional sphygmomanometer requires an expert, hence this system was used which measures the blood pressure by oscillometric method.

**KEYWORDS:** Oscillometric, Non Invasive, MPM (Multi Parameter Monitoring) system, Blood Pressure.

## **I. INTRODUCTION**

When heart beats it provides necessary energy and oxygen the body needs by pumping blood around the body. Blood Pressure, also known as arterial blood pressure, is the pressure exerted upon the walls of blood vessels by circulating blood around the body. Blood pressure measurement is also an important parameter along with other important measures such as heart rate, oxygen saturation, breathing rate and temperature that is widely used to monitor the physiological condition of human beings [1]. Blood pressure is taken as two levels and is measured in 'millimeters of mercury'. It's usually measured in terms of systolic pressure over diastolic pressure. Normal resting blood pressure of an adult is approximately 120/80 mm Hg. Blood pressure is very important to be monitored because a high and low blood pressure both can cause severe problems for a human body. BP that is low due to a disease state is called hypotension and the state when the pressure is consistently high is called as hypertension.

Survey shows that in India ten percent of the death is caused by the hypertension. The early diagnosis and treatment helps in reducing the risk of heart attacks, failures, strokes and kidney failure. Therefore accurate blood pressure measurement is vital in the prevention and detection of blood pressure related diseases.

Blood pressure can be measured either using invasive or non-invasive methods. Invasive measurements are done by penetrating the needle into the artery and the data obtained using this method is very accurate. But this method is used very rarely because it provides only less amount of freedom and is a difficult procedure and requires many medical procedures. Patients using invasive arterial monitoring system require very close supervision because there is a danger of severe bleeding if the line becomes disconnected. Whereas non invasive methods are simple and easy to handle.

The non-invasive auscultatory and oscillometric measurements are uncomplicated and faster than invasive measurements, require less expertise, no complexity, and are less unpleasant and painful for the patient [1] [2]. In non invasive auscultatory method the pressure cuff is tied usually around the patients upper arm. The cuff is then inflated with air to a pressure which is above the systolic blood pressure and this occludes the artery. Cuff is then deflated in steps from above the systolic to a lower pressure than the diastolic blood pressure. During the process of deflating the cuff from systolic to diastolic level the experts can determine the two BP values using a stethoscope held above the

# International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Special Issue 9, May 2016

artery just below the cuff. As the cuff is inflated the blood flow in the artery is completely blocked and then when the cuff is deflated the blood flow resumes and this flow generates a series of characteristics sound called the korotkoffs sound and the level at which the first korotkoffs sound is perceived indicates the systolic blood pressure and as the air is deflated the blood starts flowing with small restriction and when the cuff pressure equals the pressure contained in the artery the blood starts flowing without any restriction and the sound gradually stops, this point is marked as diastolic BP [3]. But the disadvantage of using this system is this method can cause manual errors or an expertise is required, hence we are here designing a system that uses the oscillometric waveforms for determining BP which results in less number of errors.

Oscillometry has become the most preferred method of measuring in most clinical settings. Especially in critical situations such as stroke, arrhythmia, hypertension oscillometric devices are in general more accurate and consistent than using other non invasive measuring techniques. In 2009 the measuring devices containing mercury was banned by the European commission because the metal is toxic. Sphygmomanometers which register pressure using a mercury column is still the most widely used device and is the gold standard for measuring the blood pressure readings. Taking the measurements using the traditional Sphygmomanometer requires an expert, hence the patients at home who wants to monitor his BP finds difficulty.

Home health care is one of the important emerging fields in the current century as it would help in reducing the medical expenses and it improves the life quality of patients at home level [6]. Advancement in communication techniques has helped in making this home health care into reality. The main goal of developing this system is to develop a wearable, light weight and small device that is capable of measuring blood pressure. This system is very useful for elderly, physically disabled, pregnant women's, infants and hypertensive patients.

## II. RELATED WORK

Kollanoor et al., [1] designed a NIBP measurement device using the photo plethysmo graphic technique that indicates the relative change in the pulse blood volume in the subject and compute BP from the smallest and the largest value from output signal obtained. Jin-ling et al., [2] deployed a system that takes into account the cuff pressure signal and pulse wave signal. These signals are then processed to find the BP values. Mahajan et al., [3] proposed a method that uses the korotkoffs sound to determine BP, by designing a digital stethoscope which records the korotkoffs sounds and this data is used to obtain BP values. Ribeiro et al., [5] discussed a NIBP system that calculates BP values by using the pulse wave transmit time. Data obtained from the Electrocardiogram and Photoplethysmographic signals are acquired to compute BP.

## III. NIBP SYSTEM DESIGN

### A) System Overview

The overall block diagram of the proposed system is shown in Figure.1. The system comprise of the pressure transducer, pump, valve, MPM (amplification and filtering) unit integrated with the microcontroller. The system used here uses the same mechanism of our traditional sphygmomanometer where the mercury manometer is replaced by the pressure transducer. The pressure cuff is tied around the upper arm, using pump the cuff is filled with air to a pressure slightly above the systolic pressure this stops the blood flow in the artery. The cuff is then deflated in small steps using the valve and the blood flow resumes in the artery. The pressure transducer acquires the pressure present in the pressure cuff and generates the electrical signal until the lower level.

### B) Hardware Description

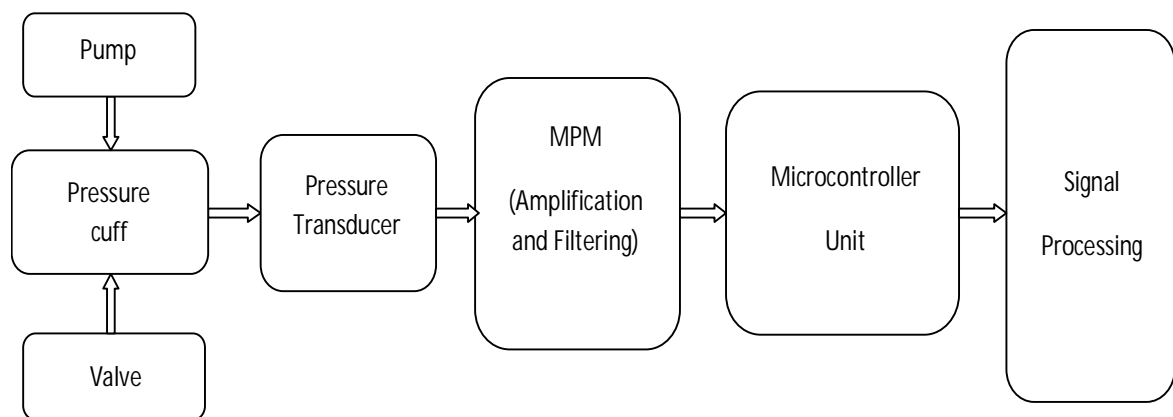
Silicon piezoresistive MPX53 series pressure transducer is used as it provides very accurate output voltage proportional to the pressure in the cuff and it has differential and gauge options [4]. The output obtained from the pressure transducer is very weak signals, because the type of transducer used is the resistive type transducer. An MPM module that performs amplification and filtering is designed using the OPA4330 operational amplifiers. The circuitry acquires the weak transducer signals amplifies and filters to their respective frequencies. The cut off frequency of low pass filter

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 9, May 2016

for blood pressure signals is 20 Hz. This module filters off the unwanted frequency range of signals from the pressure transducer. Four stage amplification is performed by the circuitry which provides better rejection, high SNR, decreases the transition width and the pass band and stop band ripple is reduced.



**Figure.1 Overall block diagram of the NIBP measurement system.**

### C) Analog to Digital conversion

Case 1 – C8051F380:

The output signal after amplification and filtering is fed into the microcontroller unit which performs the analog to digital conversion of acquired signal. The Silicon Labs C8051F380 microcontroller is used which has a high speed microcontroller core of up to 48 MIPS operation. The system consists of a 10 bit in-built ADC with a conversion speed of 500 ksp/s. The software tool used to program this microcontroller is Silicon labs IDE. Using special function registers the ADC system can be completely configured under software control.

Case 2 - ESP8266-12E:

For better resolution conversion can also be done using ESP8266-12E. The resolution of a device can be calculated using equation 1.

$$Q = \frac{V_{ref}}{2^n} \quad (1)$$

where  $V_{ref}$  is the reference voltage of the device and is equal to the maximum value that the ADC can convert. And

$2^n$  is the ADC's resolution in bits. The resolution of C8051F380 microcontroller is calculated as 0.0029 and in case of ESP8266 as 0.0009. The ESP8266 is a self contained SoC with integrated 10-bit ADC and TCP/IP protocol stack that allow the microcontroller access to Wi-Fi network. Hence ESP can be used to store the data onto the database. ESP8266 is programmed using ARDUINO software.

### D) Signal Processing

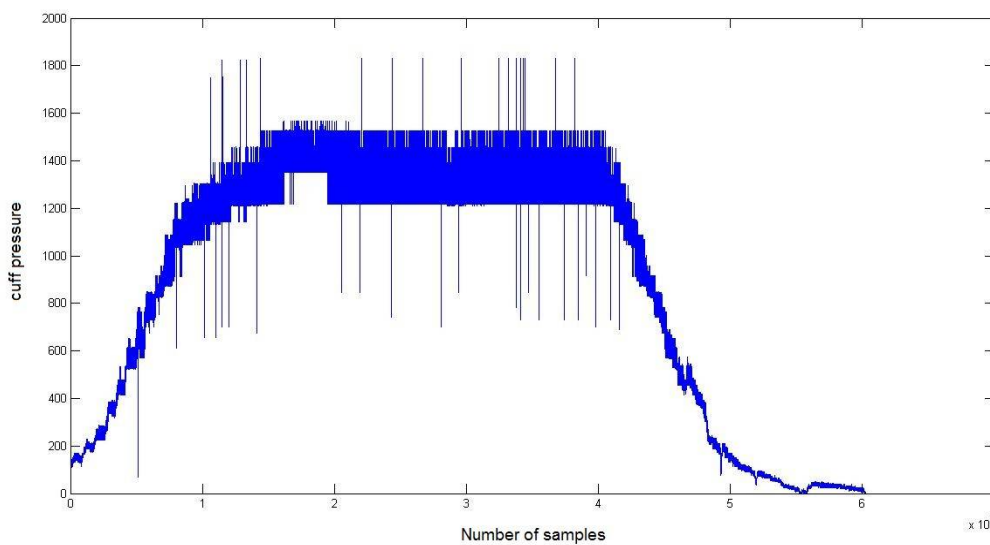
The digital filtering and simulation of the signal is performed in MATLAB. The analog to digital converted signal is now acquired and processed. The analog to digital converted output signals are represented in HEX format this is now acquired and stored in MATLAB in ASCII form. The ASCII values are converted to decimal form and are plotted in MATLAB. Plot of pressure signals obtained while using C8051F380 and ESP8266 microcontrollers are shown in Figure.2 and Figure.3 respectively. Systolic and diastolic blood pressure values can be calculated using oscillometric

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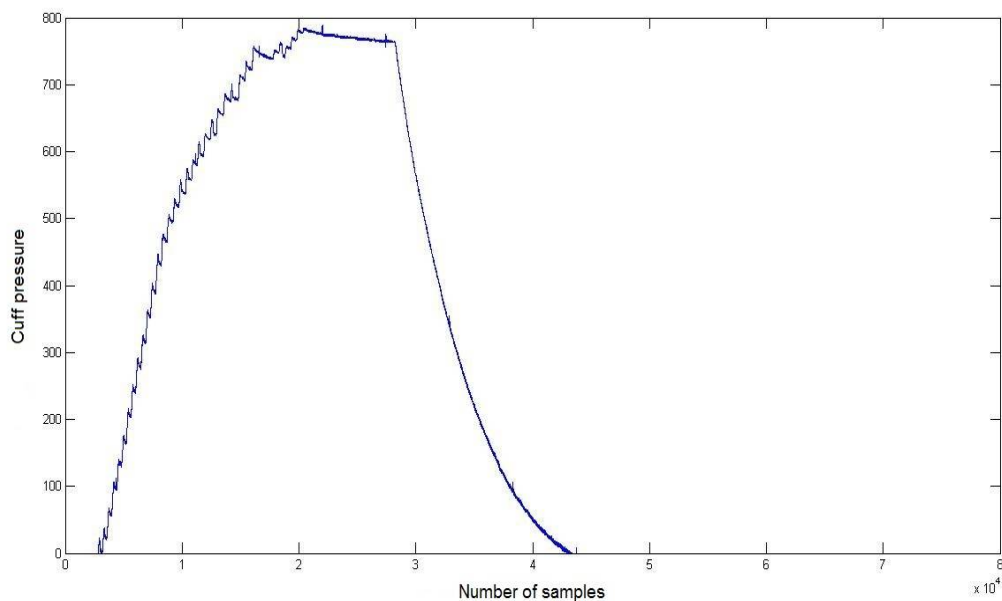
Vol. 5, Special Issue 9, May 2016

method by processing the oscillatory waveforms in the deflating path. To calculate the blood pressure values using the oscillometric method, the deflating path of the signal acquired is digital filtered and the maximum amplitude value, Amax is obtained. Corresponding to the relationship between blood pressure values and Amax, systolic blood pressure and diastolic blood pressure values can be computed [2].



**Figure.2 Pressure signal plot using C8051F380 for analog to digital conversion**

Plot of pressure signals obtained while using ESP8266 microcontroller is shown in Figure.3.



**Figure.3 Pressure signal plot using ESP8266 for analog to digital conversion**

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(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 9, May 2016

## IV. CONCLUSION AND FUTURE SCOPE

A non invasive blood pressure monitoring system that continuously acquires the real time blood pressure signals is discussed. A MPM module that performs the amplification and filtering of the blood pressure signals is designed. The blood pressure values can be obtained using the oscillometric method, hence providing the health care at home which helps in early diagnosis of the hypotension and hypertension. This work may be extended 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.

## REFERENCES

- [1] Kollanoor, Jitha J., and V. S. Suresh. "Remote Continuous Non-Invasive Blood Pressure Monitoring System With SMS Alert." *International Journal of Engineering Sciences & Emerging Technologies*, Vol. 7.3, pp. 687-692, 2014.
- [2] Jin-ling, Zhang, Liu Yue, and Wen Jia-bao. "Design of Electronic Blood Pressure Monitoring System Based on Mobile Telemedicine System." *International Conference on Complex Medical Engineering*, pp. 145-149, 2013.
- [3] Mahajan, Rutvij, Shantanu Thakurdesai, Gaurav Modak, Sumit Jottrao, and Ajinkya Bhat. "Blood pressure measurement using Korotkoff sounds." *International Conference on Industrial Instrumentation and Control*, pp. 635-639, 2015.
- [4] Freescale Semiconductor, "MPX53, 0 to 50 kPa, Differential and Gauge, Uncompensated, Silicon Pressure Sensors", MPX53 datasheet, 2015.
- [5] Ribeiro, Colunas, Marques, Fernandes and Joao, "A Real time, Wearable ECG and Continuous Blood Pressure Monitoring System for First Responders." *International conference on Engineering in Medicine and Biology Society*, pp.6894-6898, 2011.
- [6] Zhang, Yonghong, Jing Bai, and Wen Lingfeng, "Development of a home ECG and blood pressure telemonitoring center." *International conference on Engineering in Medicine and Biology Society*, Vol. 3, pp.2282-2285, 2000.