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# IoT based Automatic Blood Pressure System

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**Abstract :** ***This paper presents a method to build an IoT based automaticnon-invasive blood pressure monitor. This monitor will detect the systolic and diastolic pressures, which are used to define arterial blood pressure. The systole and diastole have been estimated using the oscillometric technique. These values are updated through Wi-Fi on to a data base, which can be accessed remotely. The results are then compared to already commercially available blood pressure monitors.***

**Keywords:** IoT, Oscillometry, Blood Pressure

## 1. Introduction

Cardiovascular diseases are now one of the leading causes of death all over the world. And arterial hypertension is one of the leading causes of cardiovascular diseases. According to a report by the World Health Organization (WHO), over a third of all the adults in the world have higher than normal blood pressure. Thus, Blood pressure is one of the most important indicators for human health in today's world.

Thus, to monitor one's health a continuous, non-invasive blood pressure monitoring system is required. Usually one's blood pressure is measured manually using a sphygmomanometer and noted down on a chart by a nurse, this requires a lot of manpower and is quite time consuming, even if patients at home could measure their blood pressure they may not fully understand what these readings indicate therefore it must be sent to a doctor for analysis. We will be using a method to measure the arterial blood pressure based on the oscillometric technique. Using this technique, we will be extracting the systolic pressure and diastolic pressure. Further, we will incorporate the concept of the Internet of Things technology into the system so that these values can be readily accessed.

## 2. Oscillometric Method

Oscillometry is now the standard for automatic Blood Pressure measuring systems. When a patient's arm is placed in a pressure chamber then the pressure of the chamber fluctuates with the pulse and the magnitude of the fluctuation varies with the pressure of the chamber.

To measure a person's blood pressure using oscillometry a cuff is placed on their upper arm, the cuff is then inflated. When the cuff is inflated to a pressure above the systolic pressure, blood flow through the artery is stopped. Then the cuff is slowly deflated, when the cuff is deflated below the systolic pressure, the reducing pressure exerted on the artery allows blood to flow through it and sets up a detectable vibration in the arterial wall. The cuff pressure continues to fall, when the pressure falls below the patient's diastolic pressure, the blood begins to flow smoothly through the artery in the usual pulses, without any vibration in the wall. Vibrations will occur at any point where the cuff pressure is high enough that the blood has to thrust the arterial wall open in order to flow through the artery [1].

The vibrations are then transferred from the walls of the artery, to the air present inside the cuff then into a pressure transducer that converts the measurements into analog electrical signals.

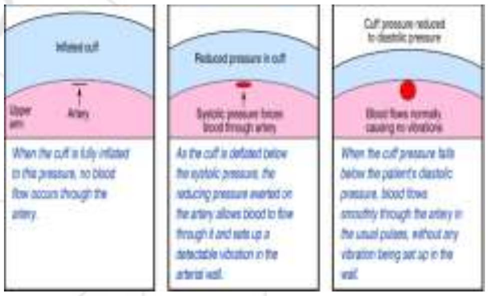


**Figure 1:** Measuring blood pressure [1]

From these signals the systolic and diastolic pressure of the person can be extracted. It may seem that the onset of the oscillations occurs at the systolic pressure and the disappearance of the oscillations occurs at the diastolic pressure but this is not the case. The onset of oscillations actually occurs well above systolic pressure and the oscillations do not disappear until well below diastolic pressure. Therefore, careful considerations must be taken when extracting the systolic and diastolic pressures.

## 3. Hardware

Using the oscillometric method, it is possible to design a device to measure blood pressure non−invasively which can be linked to the internet or any web server through the means of Wi-Fi. The block diagram of the system is given in figure.

A. Pressure Transducer and Microcontroller

A pressure transducer is a transducer that converts pressure in the cuff into an analog electrical signal; this transducer converts the vibrations in the cuff to an analog electric signal. This analog signal is then amplified and filtered using circuits to get the desired pulse waveform. The Microcontroller used is an ATmega32A, 8-bit microcontroller based on RISC architecture.

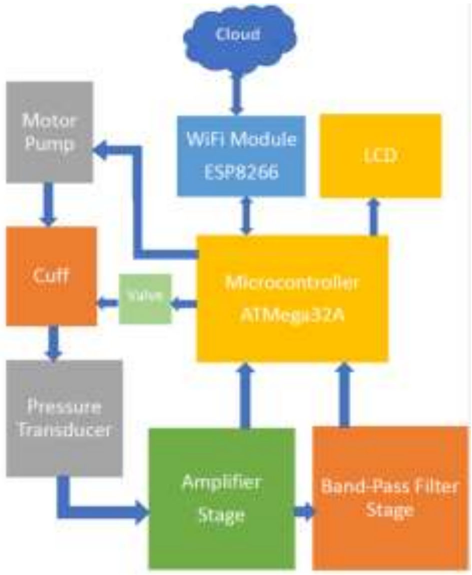


**Figure 2:** Block diagram

B. Amplifier and Filters

Since the output of the transducer is in milli-volts, an amplifier must be used to increase the resolution of the device. An instrumentation amplifier is used to amplify the signal; it is designed for a gain of 220. The frequency of human pulse wave ranges from 0.6Hz to around 6.4Hz [2]. We use a band-pass filter to extract only this range of frequencies and also to remove noise in the signal. Active bandpass filters are used so that only the pulse waveform is amplified and the DC component of the signal is removed.

The resulting waveform, as seen on a CRO is shown below.Using this waveform, the systolic pressure and diastolic pressure can be calculated.

**Figure 2:** Pulse Waveform

C. ESP8266

ESP8266 is a low-cost development board that contains GPIOs, UART, and Wi-Fi. The ESP8266 Wi-Fi module is connected to the microcontroller. This blood pressure data is transmitted using the user's Wi-Fi router to the Database, through the internet. Things Speak by MathWorks is used to collect and store the data. Thing Speak is an Internet of Things (IoT) platform that lets us collect and store the blood pressure data in the cloud.[3]

## 4. Operation

The system begins by inflating the cuff up to a pressure of 200 mmHg. The pressure in the cuff can obtain by the microcontroller from the amplifier output using Analog to Digital conversion. The microcontroller in turn controls the pump and the valve to control the pressure in the cuff. After 200mmHg is reached the pump is stopped and the cuff slowly deflates through a tiny opening. The pulse waveform is monitored, which is obtained from the bandpass filter stage. The onset of the pulses with some delay can be estimated to be at the systolic pressure and the point where the pulses go below a certain amplitude (threshold) can be estimated to be the diastolic pressure. The delay and threshold have been estimated through the trial and error method by testing several patients.

The results are then sent to the ESP8266 using UART and this is sent through the Wi-Fi module to ThingSpeak

## 5. Results

The results of the system designed are displayed below. As we can see, the results of the monitor designed are close to that of a commercially available monitor and we estimate an error of about ±7 mmHg from our comparisons with the digital monitors available commercially. It is also seen that the data is transmitted to ThingSpeak without any errors. Also, it can be noted that use of different cuff sizes lead to different values, thus proper care must be taken to ensure that the appropriate cuff size is used.

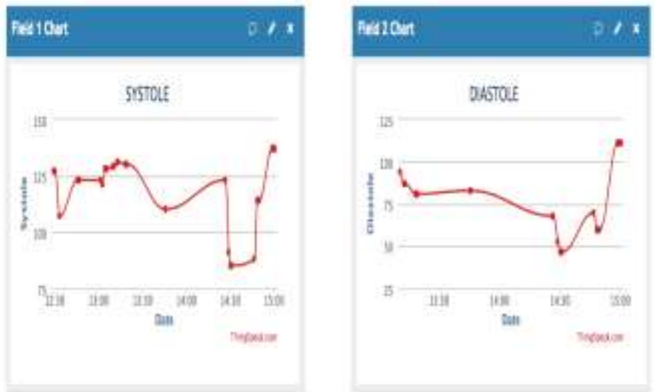


**Figure 3:** Results as seen on ThingsSpeak

I. Comparison table of our monitor with a Digital B.P. Monitor available on the market

| Trial Number | Commercial Digital B.P. Monitor | IoT Based B.P. Monitor |
|---|---|---|
| 1 | 125/85 | 132/91 |
| 2 | 132/86 | 135/94 |
| 3 | 110/72 | 114/75 |

**Figure 6:** The designed system in use

## 6. Conclusion

The designed blood pressure monitor has an accuracy of ±7 mmHg compared to the commercially available ones. This accuracy can be improved by implemented further signal processing in the designed system. The applications of such an IoT enabled device allow it be used in remote areas far away from medical support or in entire wards in hospitals using a centralized system to monitor all the patients in the ward. This system could also be extended to handle any medical device, Ex. ECG, EEG.

## 7. Acknowledgment

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