# Implementation of Digital Blood Pressure Monitor from Sphygmomanometer Using Non-invasive Oscillometric Method Using FPGA

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*Abstract*— in this research the vital signs (blood pressure, heart rate, electrocardiogram, spo2) are measured. The systolic blood pressure and diastolic blood pressure are measured. The method improved by the approaches is superior to conventional Oscillometric method. In this project the digital blood pressure meter will be implemented on FPGA XC3S1000 using HDL language. The other components will be used for the project are BLDC Motor, Cuff Belt, Pressure Sensor, Filter, AD7450. The curve fitting software module will be developed to get the output of this definition. The output will be displayed on computer. Xilinx ISE 14.6 design suite software will be used for this project.

*Key words:* SP, DP, Oscillometry, Auscaltatry, FPGA, Xilinx.

## I. INTRODUCTION

Blood pressure is the force exerted by blood against the walls of the arteries. Systolic pressure occurs when the heart contracts; diastolic pressure occurs when the heart expands. Blood pressure is measured in millimeters of mercury (mmHg). Blood pressure is affected by many factors: age, weight, time of day, activity level, climate, altitude and season. Walking can raise systolic pressure by 12 mmHg and diastolic pressure by 5.5 mmHg. Sleeping can decrease systolic blood pressure by as much as 10 mmHg. Taking your blood pressure repeatedly without waiting an interval of 5 minutes between readings, or without raising your arm to allow blood to flow back to the heart, can also affect it.

High blood pressure, also called hypertension, is a risk factor of health very frequently found in industrialized countries and it is one of the main reasons for which people visit doctors; this suffering could have very serious consequences, even the death. It happens when the blood pressure stays too high over an extended period of time and Can cause the heart to have to work too hard and the force of the blood flow can damage your arteries, heart, kidneys, brain and eyes. Before it was required a trained person to be able to measure the blood pressure of another person, because a mercury sphygmomanometer and a stethoscope were required, until the automated blood pressure monitors appeared.

Blood Pressure is a measurement of the force against the walls of the arteries as the heart pumps blood throughout the body. 1,000 Pa is about 7 mmHg. Systolic pressure is measured when the heart is beating and diastolic pressure is measured when the heart is at rest between beating. Blood pressure changes all the time. It decreases when we sleep, or when we are at rest and It increases when we are active, excited, practicing sports, stressed and nervous.

The system is divided into hardware and software part.

### *A. The hardware block diagram of automatic blood pressure monitor*

The details of required components will be as following.

#### *1) FPGA XC3S1000*

The FPGA 0XC3S1000 chip is used for digital blood pressure meter. The Spartan®-3 families of Field-Programmable Gate Arrays is specifically designed to meet the needs of high volume, cost-sensitive consumer electronic applications.

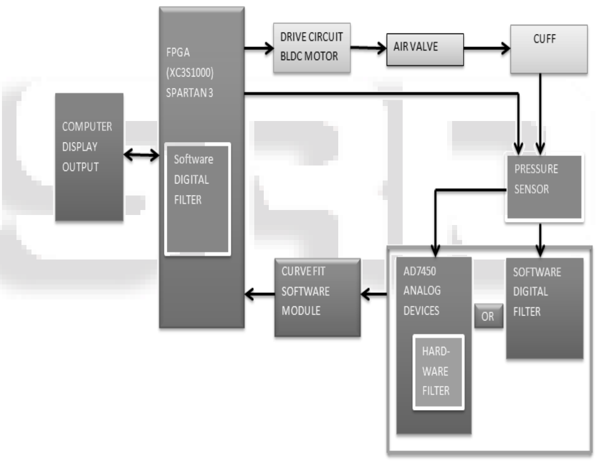


Fig. 1: Block diagram

#### *2) FPGA XC3S1000*

The FPGA 0XC3S1000 chip is used for digital blood pressure meter. The Spartan®-3 families of Field-Programmable Gate Arrays is specifically designed to meet the needs of high volume, cost-sensitive consumer electronic applications.

#### *3) Drive Circuit*

Brushless DC electric motor (BLDC motors, BL motors) also known as electronically commutated motors are synchronous motors that are powered by a DC electric source via an integrated inverter/switching power supply, which produces an AC electric signal to drive the motor Brushless motors may be described as stepper motors; however, the term stepper motor tends to be used for motors that are designed specifically to be operated in a mode where they are frequently stopped with the rotor in a defined angular position. BLDC motor is used for inflating the pressure to the cuff for my project definition.

 

#### *4) Pressure Sensor*

E8F2 is the gauge type pressure sensor is used here. It is having the pressure range about 0 to 100 KPa.

#### *5) Digital Filter*

This digital filter is the IIR (Infinite Impulse Response) filter (0.8 Hz to 10Hz frequency) which is software module is developed for this project definition.

#### *6) AD7450*

The AD7450 is a 12-bit, high-speed, low power, successive approximation (SAR) analog-to-digital converter that features a fully differential analog input. It operates from a single 3 V or 5 V power supply and features throughput rates up to 833 kSPS or 1 MSPS, respectively. This is the other option to get the output if the digital filter software module cannot be designed.

### *B. Working of all blocks of block diagram*

The fig. described here is the block diagram of my project digital blood pressure meter. FPGA XC3S1000 chip is used for this project. There are two signals which are coming out from FPGA. One signal is inserted to the drive circuit consist of BLDC motor. The pressure is inflated to cuff. The pressure to the cuff is inflated to the value added additionally up to 30 mmhg so that for some of the time pressure will be consumed in cuff. From that time to the time for deflation of pressure the oscillation readings are taken and forwarded to the ahead circuitry and displayed on computer.

The second signal from the FPGA which is of 100 Hz and 90% duty cycle is given to the pressure sensor. Pressure sensor actually converts the pressure measurements (oscillation value) to voltage readings. Here the ontime period of the feedback signal is given to the pressure sensor.

After that there will be two options for moving ahead towards the output. One is the software digital IIR filter will give the peaks by peak detection technique. The ontime period signal is converted into peaks by IIR filter. After getting the peaks the curve fitting method is used to get the curve by fitting the curve on the peaks. That value is displayed on the computer.

The other option is ADC AD7450 analog devices which will convert the voltage readings to digital form. The output of pressure sensor is voltage readings will be the input of the ADC. It will give the digital signals and the hardware filter will give the peaks and those peaks will be fitted to curve by curve fitting method. Those readings will be displayed to the computer.

### *C. Software*

It is the software that controls the hardware and processes the input signal is developed. It has the function of auto measuring the systolic and diastolic blood pressure. The flow chart is shown in figure.

### *D. Explanation of Flowchart*

This software will be implemented in VLSI with Verilog. In this software algorithm there are three important modules.

1) Input to pressure sensor
2) Software Digital Filter
3) Curve fitting algorithm

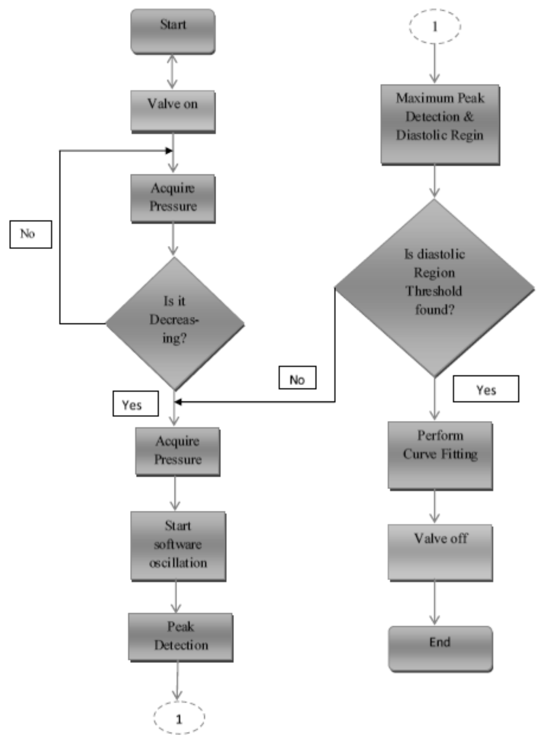


Fig. 2: Software Flowchart

In basic flow chart these following data to be executed

When Motor start, system acquire Pressure data

When Deflation start, we need pressure and software filtered oscillation During deflation When after it reach to diastolic decision point it calculate map , systolic and diastolic for multiple fraction.

In basic flow chart only one switch is required. When it will be pressed it perform all operation automatic including motor operation and valve operation.

1) Input to Pressure Sensor: Here the input signal of 90% duty cycle and 100 Hz frequency will be given to the pressure sensor. So that the pressure will be inflated to cuff and the measurements of oscillation will get.
2) Software Digital Filter: It must be of 0.8 to 10 Hz of IIR digital filter. It will convert the oscillation value in to the voltage readings by peak detection.
3) Curve Fitting Algorithm: It must be developed to get the output. It will fit the curve on the voltage readings taken from digital filter for the perfect value of blood Pressure.

## II. METHOD

Blood pressure can be measured by these types :

### *A. Invasive blood pressure (IBP)*

It measures the BP internally by using a sensitive IV catheter inserted into an superficial artery. This is the procedure taken where continuous BP monitoring is required.

### *B. Non-invasive blood pressure (NIBP)*

1) Auscultation
2) Oscillometry
3) Doppler (determines the flow distal to the artery)

 

4) Arterial tonometry, Arterial volume clamp are other types of NIBP measure

Non invasive blood pressure having Auscultation method in which the Mercury sphygmomanometer, Mechanical manometer and stethoscope are used and also having oscillation method to be used . It is based on the change of the magnitude of oscillation.

The indirect measurement is also called noninvasive measurement because the body is not invaded in the process; the most common site for indirect measurement is the upper arm where the brachial artery is located, although many other sites may be used. An occlusive cuff is placed over the upper arm of a patient the cuff is inflated at a pressure higher than the systolic blood pressure. The cuff is then gradually deflated, while a detector system determines the interest points at which the blood flow is restored. The most commonly used indirect methods are the auscultation and oscillometry, described below.

*1) Auscaltatory Method*

This method usually employs a mercury column, an occlusive cuff, and a stethoscope. The cuff is placed around the arm of the patient, when the cuff is inflated, the circulation in the artery is blocked temporarily, and when the cuff is deflated, sounds are generated because of the blood throbbing inside the artery. These sounds are monitored with a stethoscope placed on the brachial artery (Korotkoff sounds). When the first sound is listened, the blood pressure is verified in the meter: this is the systolic blood pressure, considered equal to the pumping pressure. When the sounds disappear, we have the diastolic pressure this is the pressure in the arteries when the heart relaxes between pulses. The highest number or the strongest sound is when the blood flows. Both numbers are important. [3, 4]

*2) Oscillometry Method*

Electronic pressure monitors based on oscillometry have become popular in recent years due to their simplicity of use. The principle of blood pressure measurement using this technique depends on the transmission of intra-arterial pulsations through the occluded arm. The cuff is placed around the upper arm and rapidly inflated to pressure 30 mmHg above the prospective systolic blood pressure, occluding the blood flow in the brachial artery. Then the cuff is deflated gradually while the detecting system, by means of a pressure sensor, detects the Oscillometric signal step by step. The oscillations on the arterial pressure are processed to establish an Oscillometric envelope or curve. The signal sampling is adjusted to a value determined by the value of the heart pulse.

| BP Classification | Systolic(mmHg) | Diastolic(mmHg) |
|---|---|---|
| Normal | Less than 120 | Less than 80 |
| Prehypertension | 120-139 | 80-89 |
| Stage 1 Hypertension | 140-159 | 90-99 |
| Stage 2 Hypertension | Greater than or equal to 160 | Greater than or equal to 160 |

Table. 1: Blood Pressure Readings

An individual's blood pressure varies greatly from day to day and season to season. For hypersensitive individuals, these variations are even more pronounced. Normally, blood pressure rises during work or play and falls to its lowest levels during sleep.

## III. CONCLUSIONS

I conclude that the implementation of digital blood pressure meter on FPGA can be possible by Oscillometric method using digital filter. The other method is to measure BP from the ECG heart rate signal and PPG signal. From my research work I conclude that the Oscillometric method and curve fitting method can be successfully implemented in this definition as getting the perfect waveform compare to wavelet method as well as this method is less costly and less bulky due to not using the mercury sphygmomanometer and better than the other method.

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