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DIGITAL SPHYGMOMANOMETER

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***Abstract*— the aim of our project is to design and build a prototype for the digital measurement of the blood pressure. It is the pressure exerted on the walls of the arteries when blood flows through it. It is usually denoted in terms of peak (Systolic) and minimum (Diastolic) pressure. The project aims the prototyping of a device that will automatically control the inflation of a cuff corresponding to the appearance and disappearance of the Korotkoff sounds which indicates the systolic and diastolic pressures.**

***Keywords*— Korotkoff, auscultatory, oscillometric**

I. INTRODUCTION

The determination of human blood pressure is very important to medical professionals especially for clinical studies of certain illnesses, blood hypertension classification and monitoring the condition of patients during operations. The general public measures blood pressure to check their cardiovascular health status. Blood pressure is the pressure exerted by the blood on the walls of the arteries or the blood vessels during cardiac cycle. The blood pressure varies between the systolic and the diastolic pressure.

II. PHYSIOLOGICAL ASPECT OF THE BLOOD FLOW

The human circulatory system supplies oxygenated blood to all tissues in the body. When the heart contracts it pushes the blood out into two major loops or cycles. In the systemic loop, the blood circulates into the body's systems, bringing oxygen to all its organs, structures and tissues and collecting carbon dioxide waste and this loop is controlled by the left side of the heart .the oxygen rich blood from the lungs enter the upper left chamber of the heart i.e.; the left atrium and as it becomes full it pushes open the mitral valve and blood flows into the left ventricle and when the ventricle contract the blood flows into the aorta. The aorta supplies blood to all the organs of the body thus supplying oxygenated blood. The used blood from the body is collected by the superior venecava and inferior venacava and they empty into the right atrium of the heart, and then the blood starts circulating through the pulmonary loop In the pulmonary loop, the blood circulates to and from the lungs, to release the carbon dioxide and pick up new oxygen and is controlled by the right side of the heart. The blood flows from the right atrium through the tricuspid valve into the right ventricle. They happen simultaneously and it begins with contraction of the atria to push blood into the ventricles and the ventricles contract to force blood into the arteries and then the blood flows out of the arteries through the aorta and pulmonary artery. The systolic pressure is the pressure during or resulting from systolic contraction of a cardiac chamber and it is the highest arterial blood pressure reached during any given ventricular cycle. The diastolic blood pressure is the pressure after the contraction of the heart while the chambers of the heart refill with blood.

The systolic blood pressure and diastolic blood pressure for a normal human being is given 120/80 (120 refers to the systolic blood pressure and 80 refers to diastolic blood pressure).

III. MEASUREMENT OF BLOOD PRESSURE

Blood pressure measurement(BPM) can be classified into two groups, invasive (direct) and non-invasive (indirect).Invasive techniques is one where a needle like probe or catheter is inserted through the vein or artery to the area of interest which brings high risks of embolism, arrhythmia, heart attack and a certain percent of mortality. Non-invasive pressure measurement technique includes measurement of pressure by the use of cuff over limb containing artery and doesn't involve any kind of insertion through veins or artery.

The non-invasive technique is preferred in case of BP measurement as it could provide almost accurate results and isn't complex as it doesn't involve any intrusion by penetrating the arterial wall to take the measurement and Measuring pressure invasively is much less common and usually restricted to a hospital setting. The non-invasive methods may yield lower accuracy and small systematic differences in numerical results. Non-invasive measurement methods are more commonly used for routine examinations and monitoring.

The non-invasive pressure measurement is done using a sphygmomanometer, which historically used the height of a column of mercury to reflect the circulating pressure. A cuff is wound tightly across a limb containing artery and pumped up with air so as to occlude the flow of blood through the artery. as the pressure in the cuff is raised beyond the pressure of the blood , the flow of blood stops and as the pressure in the cuff is slowly decreased , the blood starts to flow and as the pressure in the cuff equals to the patient's systolic blood pressure, the first Korotkoff sound will be heard This blood flows in spurts as the pressure in the artery rises above the pressure in the cuff and then drops back down

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beyond the cuffed region, resulting in turbulence that produces an audible sound. As the pressure in the cuff is allowed to fall further, thumping sounds continue to be heard as long as the pressure in the cuff is between the systolic and diastolic pressures, as the arterial pressure keeps on rising above and dropping back below the pressure in the cuff. Eventually, as the pressure in the cuff drops further, the sounds change in quality, then become muted, and finally disappear altogether. This occurs because, as the pressure in the cuff drops below the diastolic blood pressure, the cuff no longer provides any restriction to blood flow allowing the blood flow to become smooth again with no turbulence and thus produce no further audible sound. The analog blood pressure measurement is when a stethoscope is placed over the brachial artery in a normal person (without arterial disease), and the korotkoff sounds are heard using it and a doctor records manually the exact pressure of the occurrence of the first and the last korotkoff sound indicating the systolic and diastolic pressures.

The digital blood pressure non-invasive monitoring system is based on the same principle except the korotkoff sound is detected using a microphone and the microcontroller is programmed to record the pressure corresponding to the exact occurrence of the korotkoff sound.

IV. TYPES OF BP MEASUREMENT

There are various principles that can be employed for blood pressure measurement. The commonly used methods are auscultatory and oscillometric blood pressure measurement

A. Auscultatory method

The cuff is placed over the limb containing the artery and the cuff is inflated above the systolic blood pressure .The increase in pressure occludes the flow of blood through the artery .As the pressure in the cuff is raised beyond the pressure of the blood, the flow of blood stops and as the pressure in the cuff is slowly decreased, the blood starts to flow and as the pressure in the cuff equals to the patient's systolic blood pressure, the first Korotkoff sound will be heard. This blood flows in spurts as the pressure in the artery rises above the pressure in the cuff and then drops back down beyond the cuffed region, resulting in turbulence that produces an audible sound. As the pressure in the cuff is allowed to fall further, thumping sounds continue to be heard as long as the pressure in the cuff is between the systolic and diastolic pressures, as the arterial pressure keeps on rising above and dropping back below the pressure in the cuff. Eventually, as the pressure in the cuff drops further, the sounds change in quality, then become muted, and finally disappear altogether. This occurs because, as the pressure in the cuff drops below the diastolic blood pressure, the cuff no longer provides any restriction to blood flow allowing the blood flow to become smooth again with no turbulence and thus produce no further audible sound. The Korotkoff is categorized as five types of sounds:

1. The first Korotkoff sound is the snapping sound first heard at the systolic pressure. Clear tapping, repetitive sounds for at least two consecutive beats are considered the systolic pressure.
2. The second sounds are the murmurs heard for most of the area between the systolic and diastolic pressures.
3. The third sound was described as a loud, crisp tapping sound.
4. The fourth sound, at pressures within 10 mmHg above the diastolic blood pressure, was described as "thumping" and "muting".
5. The fifth Korotkoff sound is silence as the cuff pressure drops below the diastolic blood pressure. The disappearance of sound is considered diastolic blood pressure -- 2 mmHg above the last sound heard.

The second and third Korotkoff sounds have no known clinical significance.

B. Oscillometric method

The occluding cuff that is placed over the limb containing artery is slowly deflated and as the pressure in the cuff equals the systolic pressure, the artery walls begin to vibrate and the vibrations are sensed and systolic and diastolic pressure are determined. The point of maximal oscillation corresponds to the mean intra-arterial pressure. The oscillations begin at approximately systolic pressure and continue below diastolic, so that systolic and diastolic pressure can only be estimated indirectly according to some empirically derived algorithm. One advantage of the method is that no transducer need be placed over the brachial artery, so that placement of the cuff is not critical. Other potential advantages of the oscillometric method for ambulatory monitoring are that it is less susceptible to external noise (but not to low-frequency mechanical vibration) and that the cuff can be removed and replaced by the patient .The main disadvantage is that such recorders do not work well during physical activity, when there may be considerable movement artefact.

We have decided to implement the auscultatory method of measurement as all kinds of artifacts are ignored to give us accurate results.

V. EXPERIMENTAL SETUP

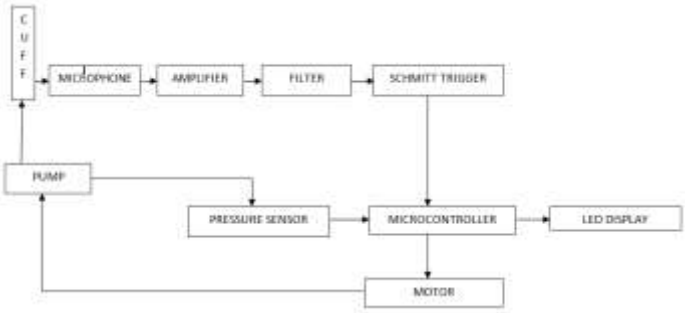

Fig.1 Block diagram of the digital sphygmomanometer setup

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A. *Pump*

The pump for inflation of the cuff must be appropriately selected as the sudden increase or decrease in pressure of the cuff used to occlude the artery can cause discomfort or pain to the patient. The pump pressure must be increased at a constant rate during the inflation of the cuff and the deflation rate of the cuff should be around at a very low rate for accurate detection of the Korotkoff sound.

B. *Pressure sensor*

Various kinds of pressure sensors were researched and we have chosen the piezoelectric type of pressure sensor to obtain accurate results.

- Piezo-electric Transducers
  - Works on varying potential when stress is applied across it.
  - Smaller lifetime but can be improved by using on polysilicon layer
- Capacitive Transducers
  - Works on varying position of the dielectric
  - Large lifetime compared to Piezo-electric Transducers

The pressure sensor we have used is the pp02 pressure sensor which has a pressure sensor of 0- 37 kpa.

C. *Filter*

The filter used to range of Korotkoff sound is a second order band pass filter that is designed using low pass filter and a high pass filter. The amplifier has a gain of 1000 as the Korotkoff signal has a peak voltage at 10μV, so the signal has to be amplified before filtering.

Fig. 2 Block diagram of the filter

The Low pass Filter Parameters of the 2nd order sallen-key LPF

DC gain = 1; Quality factor=1/2; Cut off frequency = 100 Hz; Resistance= 64kΩ Capacitance= 100nF

The High Pass Filter Parameters of the 2nd order sallen-key HPF

DC gain = 1; Quality factor=1/2; Cut off frequency = 25 Hz; Resistance= 16kΩ Capacitance=100Nf

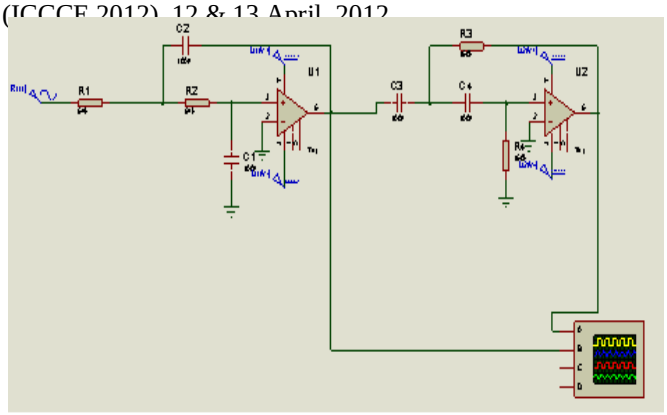

Fig 3 simulation diagram of the filter

Fig 4 simulation result of the filter

D. *Schmitt trigger*

The Schmitt trigger is used to send a constant voltage output to the microcontroller immaterial of the amplitude of the electrical signal received by the microphone from the human body.

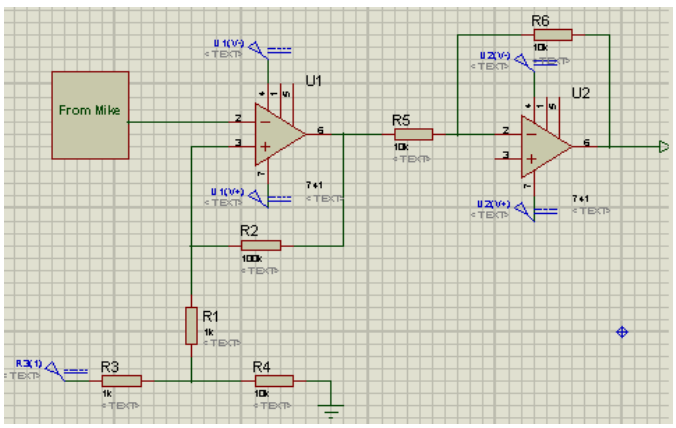

Fig 5 simulation diagram of the schmitt trigger

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E. Motor driving circuit

The monitor uses the L293D IC for the motor driving circuit.

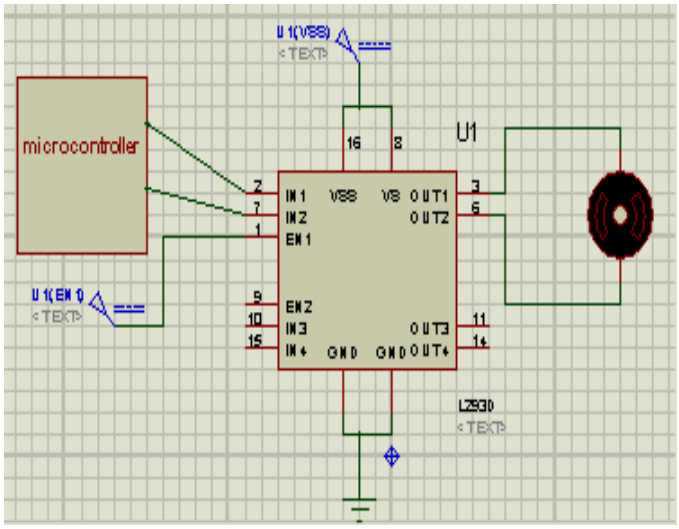
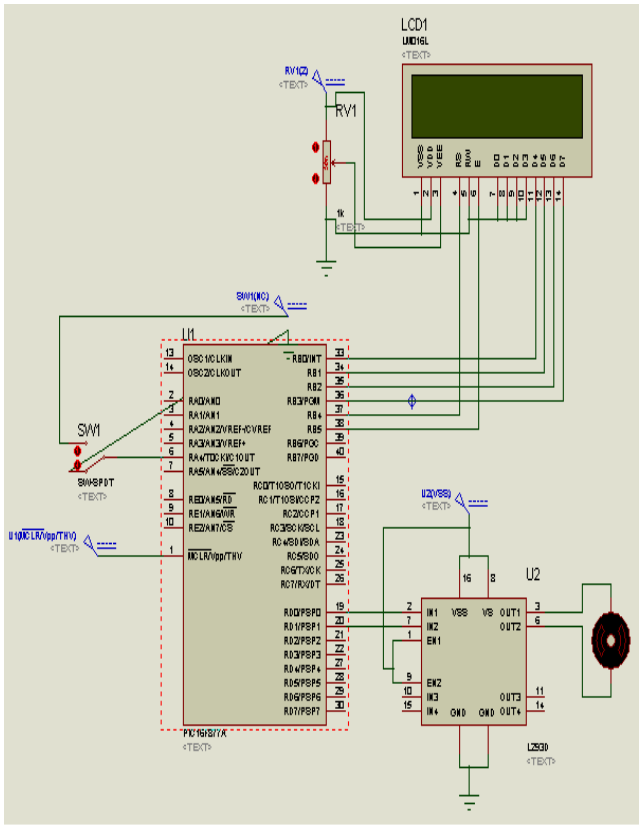


Fig 6 simulation diagram of the motor driving circuit

F. Overall simulation diagram



VI. CONCLUSION

The high rate of hypertension in the adult population and its harmful effects, the measurement of arterial blood pressure is of great clinical significance. Manual sphygmomanometer, developed more than a hundred years ago, is currently the most accurate non-invasive technique for arterial blood pressure measurement. Since manual sphygmomanometer requires a well-trained examiner, only single measurements of blood pressure will generally be performed by a physician during a given visit. This single measurement only provides partial information since blood pressure changes spontaneously. The available automatic blood pressure meters, mainly based on auscultatory can be used at home but some of them are of low accuracy.

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