HARDWARE DEVELOPMENT OF DOPPLER ULTRASOUND BLOOD FLOWMETER

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Abstract – *The paper is about the development of ultrasound blood flow meter. This ultrasonic circuit consists of transmitter and receiver part. The experiment or measurement will be dealing with normal blood flow and factor that influent the blood flow part in human being. This project is mainly focus on monitoring the blood flow due to some factor that affects the blood flow.*

1.0 INTRODUCTION

Doppler instruments often quantify the rate of movement or speed of the moving interfaces within the sound beam. [1] Although some instrument uses the Doppler principle to detect motion, the manner in which the Doppler signals are acquired, processed and displayed distinguishes one typed instrument from other. [1]In Doppler instrumentation, principles of Doppler Effect are used for making non invasive velocity measurement of blood flow. The Doppler Effect is a physical phenomenon in which an apparent change in the frequency of the sound was observed if there is relation motion between the source of the sound and receiver of the sound. [1]

A sound wave propagating in a moving medium is affected by the velocity of the medium, and the sound scattered by a moving object is also affected by the velocity of the scattering object. Both phenomena can be used to measure blood flow velocity or flow rate in blood vessel. [2] In the blood flowmeter, transmitter sent out ultrasound pulse into body and observe the change in frequency that occur when it reflected or scattered from the target .The receiver instead of measuring how much energy is reflected back from the moving target in the body. Moving target returns that frequency shifted by an amount proportional to its velocity. The difference between the transmitted frequency and the observed frequency is called the Doppler shift. The amount of change in frequency depends on how rapidly the sound source, receiver, or both are moving. [1] The Doppler shift can be determined by the following equation:

$$f_D = \frac{2fv}{C} \qquad [1]$$

Where:

f_D = Doppler frequency
f = frequency of the transducer
C = velocity of sound in tissue
v = velocity of the interface

In blood flow measurement, the sound beam incident at some angle. From Equation [1], Doppler shift frequency equation can be measured. The moving velocity also can be determined by the following equation:

$$f_D = \frac{2fv\cos\theta}{C} \qquad [2]$$

where:

Θ = angle of inclination of the incident wave to the direction of blood flow.

v = velocity of blood cells.

Rearrange the equation, velocity of the blood, can be determined by the following equation:

$$v = \frac{f_D.C}{2f\cos\theta} \qquad [3]$$

The actual determination of the Doppler angle may be very difficult. The minimum shift should be at a 90 degree incident because the cos 90 degree equal to zeros. In practice, the signal never goes to zero because some portion of the beam is not perpendicular to the motion as a result of divergence. A conceptual of ultrasound Doppler Shift blood flowmeter is shown in Figure 1. Ultrasound frequency was transmitted by transmitter. The incident ultrasound is scattered by the blood cells and the scattered wave is received by receiver. The frequency shift due to the moving scatterers is proportional to the velocity of the scatterers.

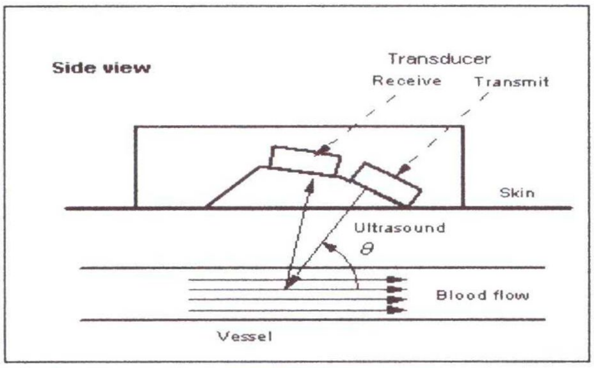

Figure 1: Principle of ultrasound Doppler Shift blood flowmeter

2.0 OBJECTIVES

The objectives of this project is to investigate the effect blood flow velocity in term of varying frequency, limitation of the blood flow due to pressure effect and movement.

3.0 METHODOLOGY

The project was design to build up a Doppler circuit and calibrate the units. Most of these steps involving testing circuits and then comparing the result. The steps are shown in Figure 2. Hardware was constructing with suitable circuit. Before start the experiment, transmitter frequency was setting from the oscillator. Then transmitter electrode and receiver electrode were put to subject arm and shifted frequencies receive by receiver were analyzed using oscilloscope to determined blood flow velocity. Then transmitter electrode and receiver electrode position were checked to get better waveform.

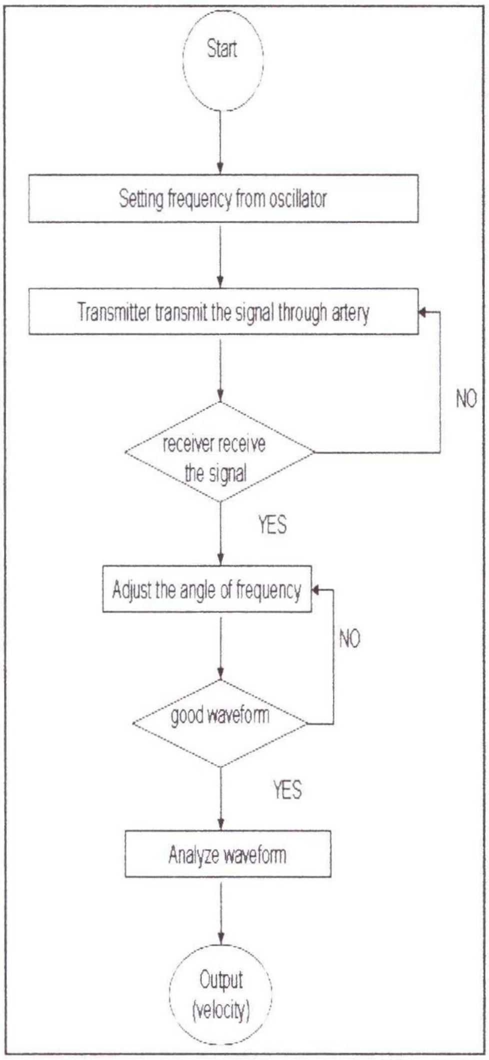

Figure 2: Flow chart for the blood flow experiment and measurement

4.0 HARDWARE DEVELOPMENT

In hardware construction, PCB ultrasound circuit's layout was design using DXP 2004 where at PCB layout, point A and B was connected to transmitter electrode, point C was connected to oscillator, and point D and E was connected to receiver electrode. PCB layout was shown in Figure 3. PSpice software was use to draw schematic circuit was shown in Figure 4.

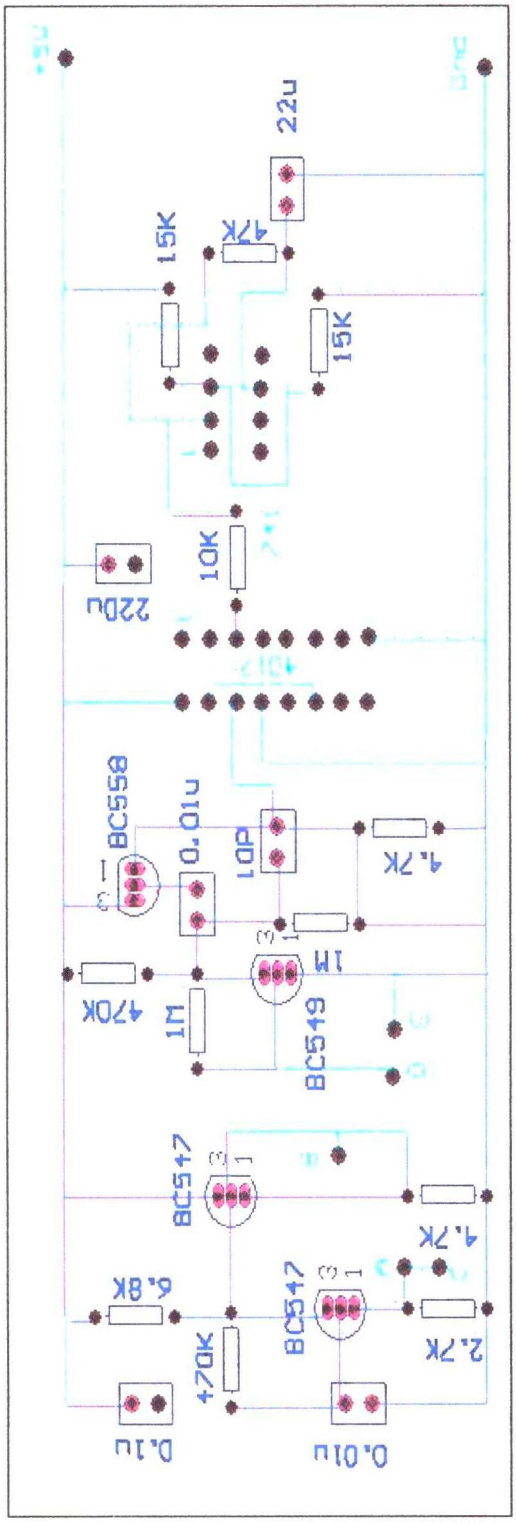

Figure 3: PCB layout of ultrasound circuits

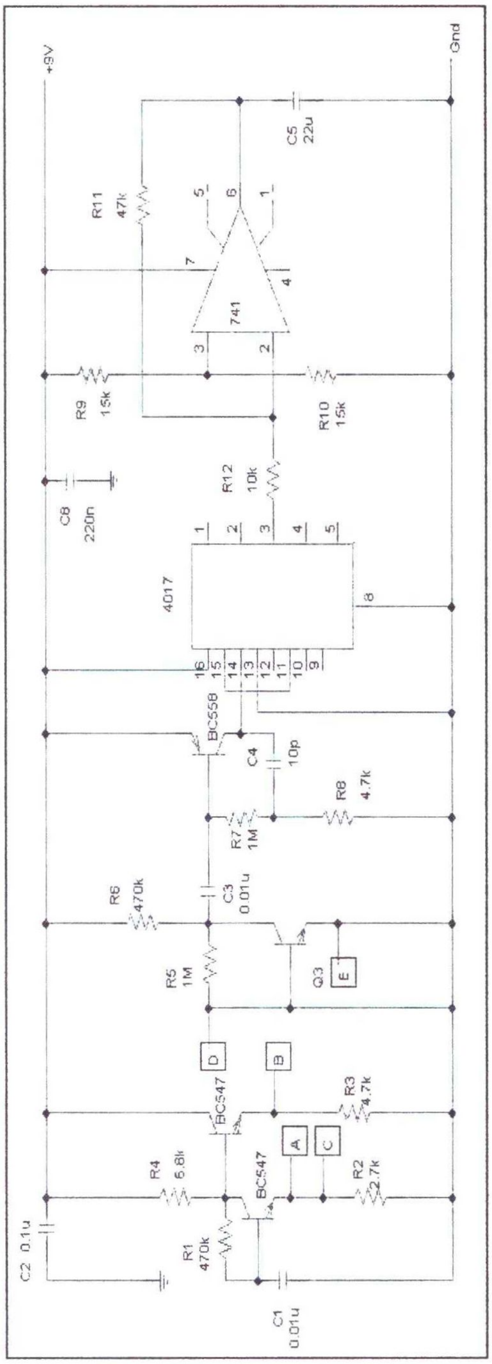

Figure 4: Schematic design ultrasound circuits

To achieve output from the hardware, several testing have been done using oscilloscope and the result achieved will be discussed. Hardware construction was shown in Figure 5. Experiment was running to find factor influent blood flow velocity and in Figure 6, Sphygmomanometer was attached to subject arm to find blood flow effect due to pressure effect.

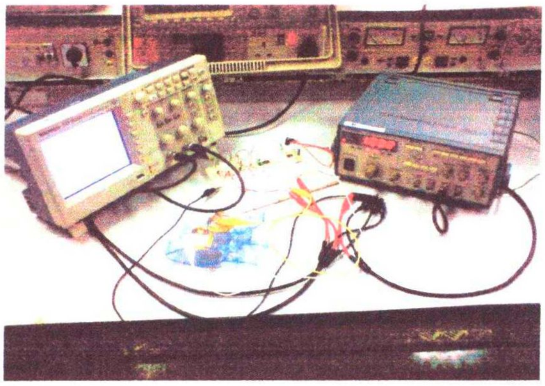

Figure 5: Hardware construction

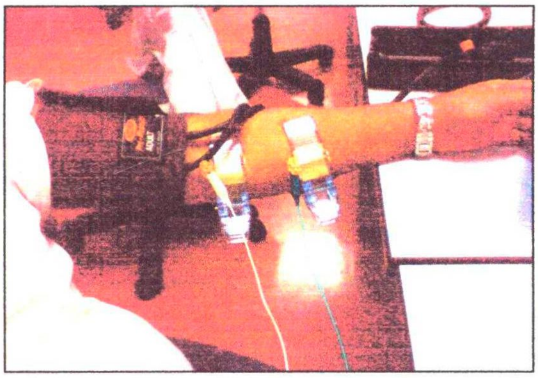

Figure 6: Sphygmomanometer was attached to subject arm to find factor influent blood flow due to pressure effect.

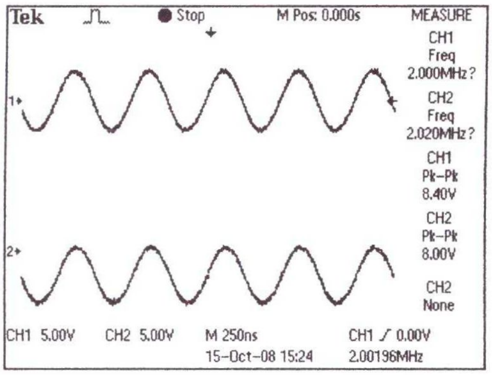

Figure 7: Receiver at channel 2 was received 2.020MHz where transmitter and receiver were separate in range 2 inch

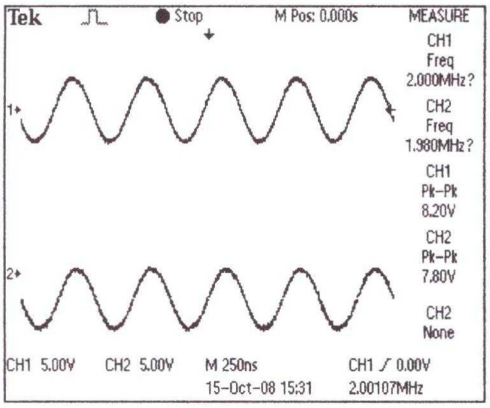

Figure 8: Receiver at channel 2was received 1.980MHz where transmitter and receiver were separate 4 inch

5.0 RESULT

5.1 Experiment I: To obtain the higher velocity due to range of transmitter and receiver.

Result in Figure 7 shows, receiver at channel 2 was received 2.020MHz, where transmitter and receiver were separate in range 2 inch. In Figure 8, receiver at channel 2 was received 1.980MHz, where transmitter and receiver were separate in range 4 inch.

5.2 Experiment II: To obtain the limitation of the blood flow due to pressure effect.

Result in Figure 9 shows receiver at channel 2 was received 1.976MHz when pressure from Sphygmomanometer was applies to the subject arm and frequency at receiver was slowly increase to normal condition.

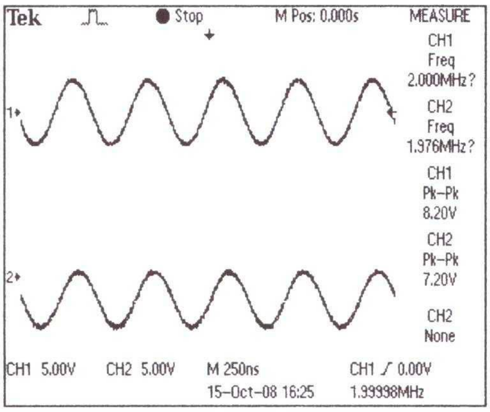

Figure 9: Receiver at channel 2 was received 1.976MHz due to pressure effect

5.3 Experiment III - to obtain the effect of subject movement.

Receiver received varying frequency during subject movement with load. Figure 10 shows, at channel 2 frequency was received 2.020MHz. While channel 2 in Figure 11 shows, frequency was received 3.817MHz.

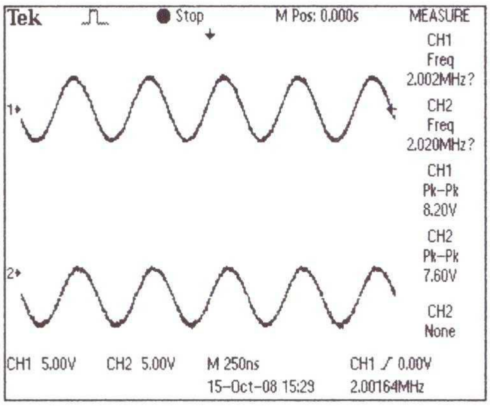

Figure 10: Receiver at channel 2 was received 2.020MHz due to subject movement

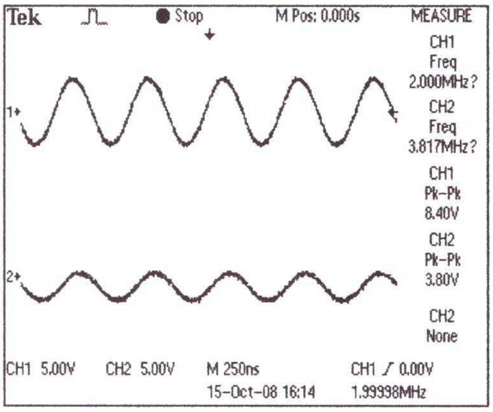

Figure 11: Receiver at channel 2 was received 3.817MHz due to subject movement

6.0 DISCUSSION AND CONCLUSION

From the experiment, it can be conclude that the range, pressure and movement influent the blood flow velocity.

Experiment I show that transmitter and receiver separation length at range 2.0 inch give high blood flow velocity than other separation length and Table 1 shows that blood flow are varying due transmitter and receiver separation. At length 2.0 inch, receiver was received 2.020MHz and blood flow velocity is 777.70m/s. When transmitter and receiver was separate at length 4.0 inch, receiver was received 1.980MHz and blood flow velocity is 762.30m/s

Table 1 shows the effect of separation transmitter and receiver with velocity

Length seperation	Frequency transmitted	Frequency at receiver	Blood flow (m/s)
0.5	2.00E+06	2.012E+06	774.62
1.0	2.00E+06	2.016E+06	776.16
1.5	2.00E+06	2.012E+06	774.62
2.0	2.00E+06	2.020E+06	777.70
2.5	2.00E+06	2.018E+06	776.93
3.0	2.00E+06	1.992E+06	766.92
3.5	2.00E+06	1.988E+06	765.38
4.0	2.00E+06	1.980E+06	762.30

In Experiment II, blood flowing slowly due to pressure from Sphygmomanometer that applied to subject arm. Receiver was measured

1.976MHz in the beginning and blood flow was 760.76m/s. Blood flow was slowly increase to normal condition

Experiment III shows frequency at receiver are changing drastically due to subject movement. In normal condition without movement, blood flow is 776.16m/s and during experiment, blood flow varying from 777.7m/s to 1469.55m/s. The difference blood flow percentage between normal condition and movement are 44.77%.

7.0 ACKNOWLEDGEMENT

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8.0 FUTURE DEVELOPMENTS

Firstly to get better waveform, circuit should de add some additional circuit like rectifier circuit and filter circuit. Secondly interface hardware with software such as C++. Databases that have been stored in C++ can analyze human health.

9.0 REFERENCES

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