The Improvement of Phonocardiograph Signal (PCG) Representation Through the Electronic Stethoscope

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***Abstract*— A conventional stethoscope (an acoustic stethoscope) is an acoustic medical device that is always used for preliminary examination of patients with any heart abnormalities. The main disadvantage of acoustic stethoscope is its dependence on how to use it and the experience of the examining physician. This paper presents a simple electronic stethoscope design in Phonocardiograph system that is free from subjectivity of doctors or other medical personnel. This electronic stethoscope is made sensitive in order to capture as many acoustic signal as possible from the activities of the human body, especially the heart and lungs. The design of this electronic stethoscope consists of chest piece, a pipe with proper acoustic impedance, mic condenser, mic preamp, and battery. The output of the mic preamp is connected to the mic channel on the laptop. The recording signal then processed separately. The repeatability of output signal was investigated in this paper. The signal was analyzed by using the Fast Fourier Transform (FFT). The result showed that the frequency responsea of the output signals are consistent, hence the instrument is reliable. Furthermore, the frequency response of the system with filter that connecting chest piece and mic condensor were also investigated.**

***Keywords*—PCG, heartbeat signal, FFT**

I. INTRODUCTION

Heart disease is the worldwide leading cause of death. Early detection of heart disease is necessary to prevent worse things such death from happening. Cardiac abnormalities can be detected from heartbeat with the help of a stethoscope. However acoustic stethoscopes have weaknesses such as less sensitive and susceptible to noise[1]. In addition it also needs special skills in using stethoscope. The use of a stethoscope is subjective in that it affects the level of its accuracy. Acoustic stethoscope is also cannot hear heart sounds under certain frequency, while the components are sometimes carries important heart information [2] [3].

Electronic Stethoscope in Phonocardiography System (PCG) was developed to modify the deficiencies of stethoscope. PCG system has a high sense of sound components that can not be heard by acoustic stethoscope [2]. PCG is a non-invasive diagnostic technique that can help to compare the cardiac acoustic signals obtained from the normal to those with the diseases [4]. PCG is a medical device that is inexpensive, simple and easy to use. Phonocardiography signal (PCG) can be utilized more efficiently by doctors where it can be visually visibleand can be recorded, hence it can eliminate the element of subjectivity [5].

Heart beat comes from the open and close of the heart valve, each of which is named S1 and S2. S1 sound associated with the closure of the atrioventricular valves when blood flows from atria to ventricle. While sounds of S2, associated with the closure of aortic and pulmonary valves when blood flos from the heart to the lung. Systolic intervals starting at the beginning of the early S1 to S2, whereas diastolic interval starts at the beginning of the next S2 to S1. In addition to the components of S1 and S2, some abnormal sound components called murmur can occur during both systole, diastole, or during the two periods. Murmurs can be caused by structural abnormalities and should be detected in the aucultation system. Period consisted of systolic and diastolic periods is known as heart beat cycle and the basis of heart sounds analysis and can be source of information which show health conditions [6] [3] [5] .

The hardware realized in this paper is based on the preliminary design reported in [7]. The objective is to produce a high quality digital stethoscope that affordable enough. In the previous research PCG systems has been designed and built and consisting of chest piece, pre-amp, and data processing sysytem. This study aims to investigate the reliability of PCG system by mesuring the frequency response of the signals for the heart beat of the same person in the same condition but with different time. To enhance the heart beat signal. filtering component is alos neededIn addition this paper also investigate the effect of the using of pipe as filter that connects chest piece to the mic condenser by measuring the frequency response of the signal.

II. RESEARCH METHOD

The first step is to build the PCG system and the design of PCG circuit like in Fig. 1.

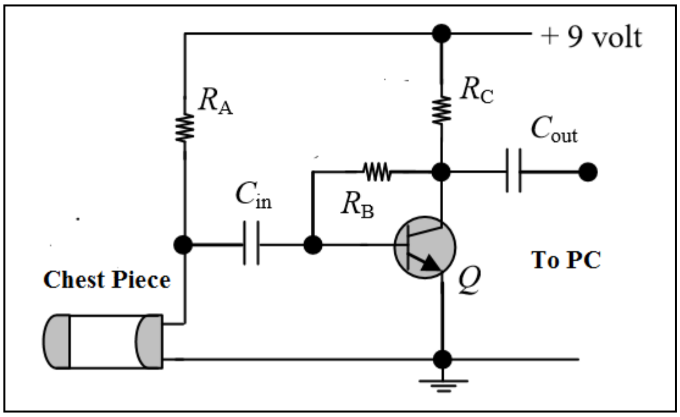

Figure 1. PCG system

The sound of the heart is captured by the chest piece and will be passed to the condenser mic then will be amplified by the pre-amp. Once amplified the signal can be stored into the computer for further processing.

To make sure that the system is reliable, the repeatability of the output signal has to be measured and this is done by measuring the frequency response of the heart beat signals of the same person in different time by using Fast Fourier Transform (FFT). The data recorded for 15 seconds and the data segmented by pick one cycle of systole and diastole. One segmentation that process by using FFT to find the frequency response.If the system is reliable the frequency response shoud show the same component for the same person.

After making sure that the PCG system is repeatable, the next step is to add pipe that acts as a filter that connects chest piece to the mic condensor. The block diagram of the system depicted in Fig. 2

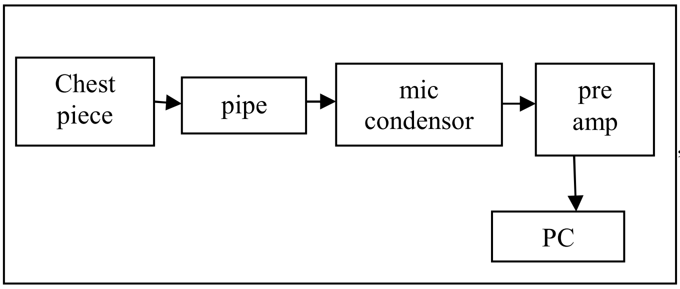

Figure 2. PCG system with filter

III. DATA ANALYSIS

The data of heart beat signal that is recorded depicted in Fig. 3. The data that is recorded using no filter or pipe.

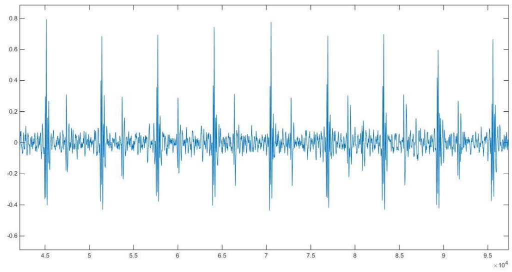

Fig. 3. The heart beat signal

The next step is segmenting the data. Tha part of data that is used for further analysis is the data for a cycle of one systole and one diastole as depicted in Fig. 4

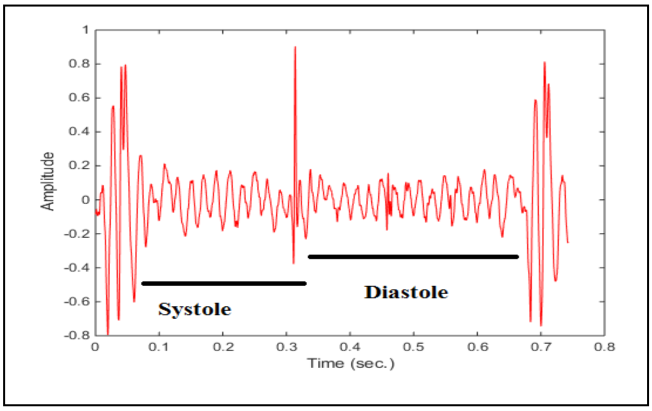

Fig. 4. One cycle of Systole and Diastole

The data segmenting was taking since the beginning of S1 and ended after the end of S1 in the next cycle. Hence it consists of one cycle os Systole and Diastole. After segmenting, the data then analyzed using Fast Fourier Transform.Fig. 5 – Fig. 9 depicted the frequency response of signals from PCG system of 5 data sampling. The graphs show that the frequency response consist of certain components.

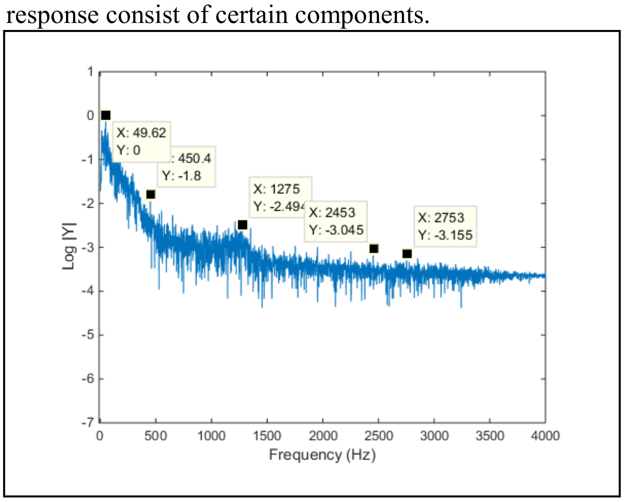

Fig. 5. FFT result of first data sampling

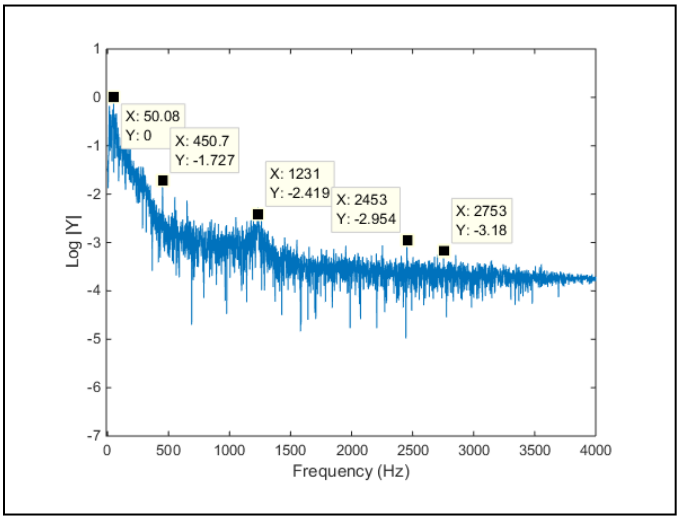

Fig.6 FFT result of second data sampling

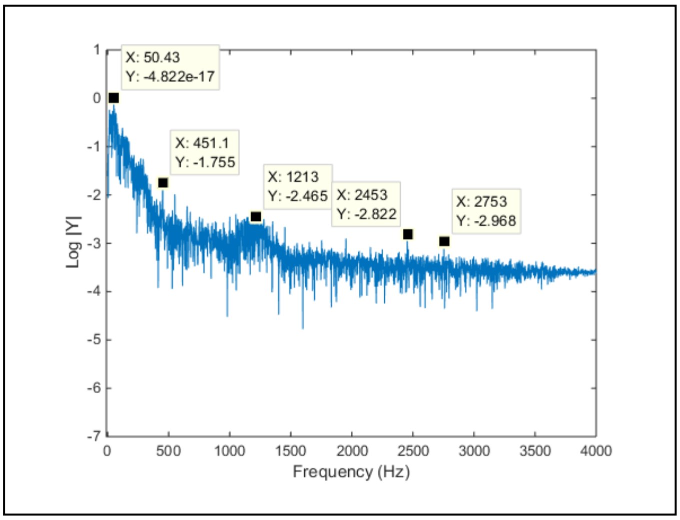

Fig. 7. FFT result of third data sampling

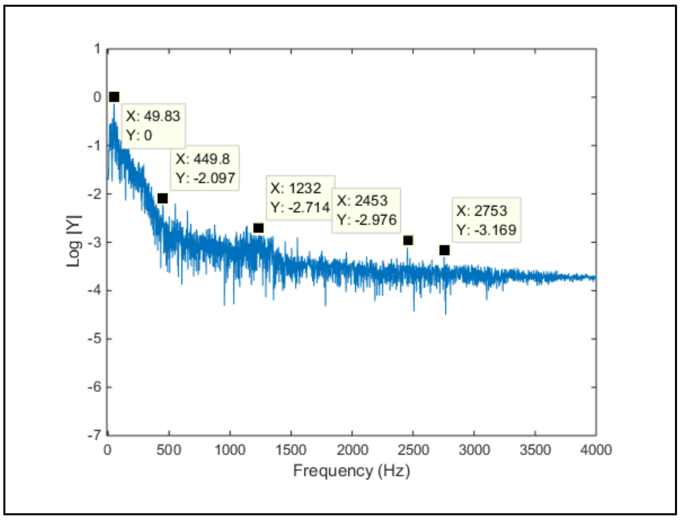

Fig. 7. FFT result of fourth data sampling

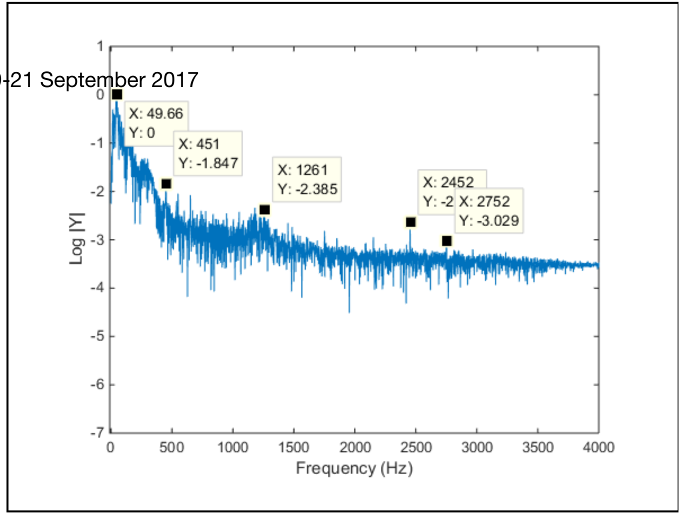

Fig. 9. FFT result of fifth data sampling

The FFT result show that for heart beat sample of the same person in different time has the same frequency component. The graph also bend in the same frequency range which is around 450 Hz. This is showed that the system is reliable and repeatible. The detail of the data showed in table 1.

TABLE I. THE FREQUENCY COMPONENT OF EACH DATA SAMPLING

Data Sampling	**Frequency Component (Hz)**				
	First	Second	Third	Fourth	Fifth
First	49.62	450.4	1275	2453	2753
Second	50.06	450.7	1231	2453	2753
Third	50.43	451.1	1213	2453	2753
Fourth	49.83	449.8	1232	2453	2753
Fifth	49.66	451	1261	2452	2752

After proving the system is reliable, the next step is to connect a pipe that acts as filter to enhance the signal. The pipe is made of plastics andthe length were varied. The lengthe of pipe that was used are 360 cm, 450 cm, 480 cm, 500 cm, 600 cm, 760 cm and 1000 m.

The FFT result of signal that has been filtered showed different frequency component than those who has not been filtered. In the beginning of signal the peak is about 50 Hz but then the graph go down and bend before it reach stability. Every different pipe has different frequency component. For ecxample, the signal with 360 cm pipe bend in 753 Hz, 450m bend in 377.2 Hz, etc.

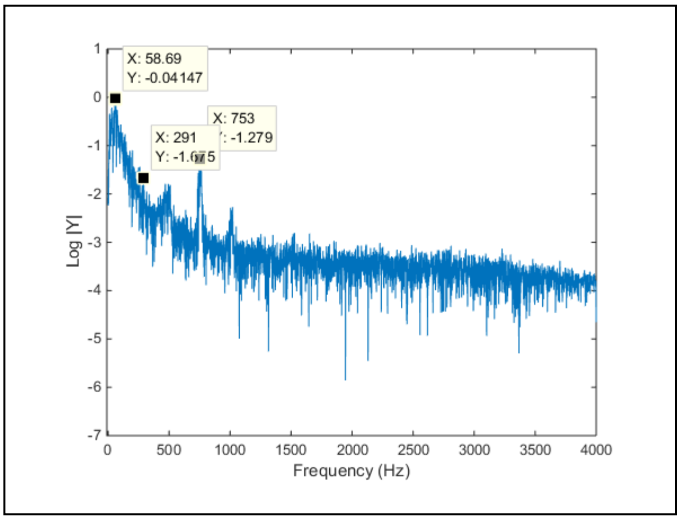

Fig. 10. FFT analysis for pipe of 360 cm length

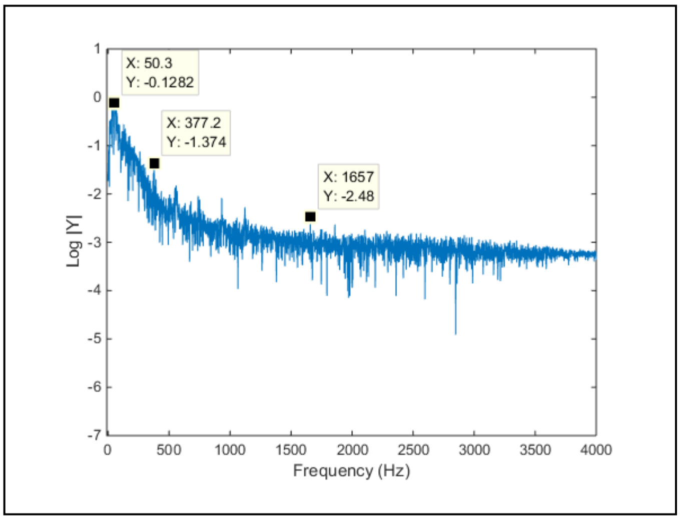

Fig. 11. FFT analysis for pipe of 450 cm length

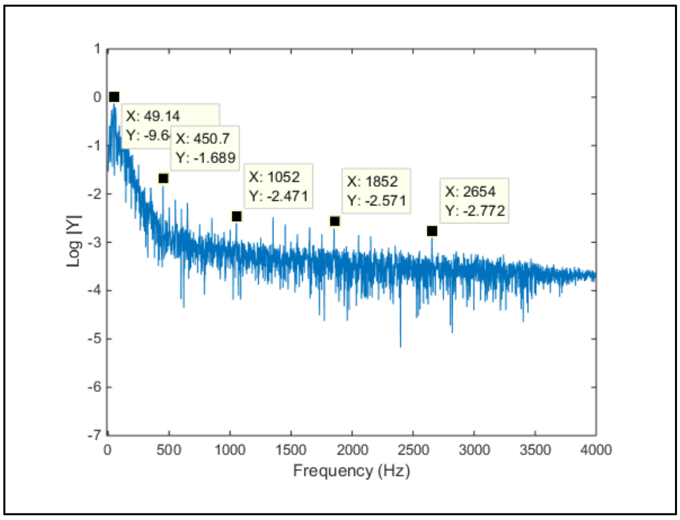

Fig. 12. FFT analysis for pipe of 480 cm length

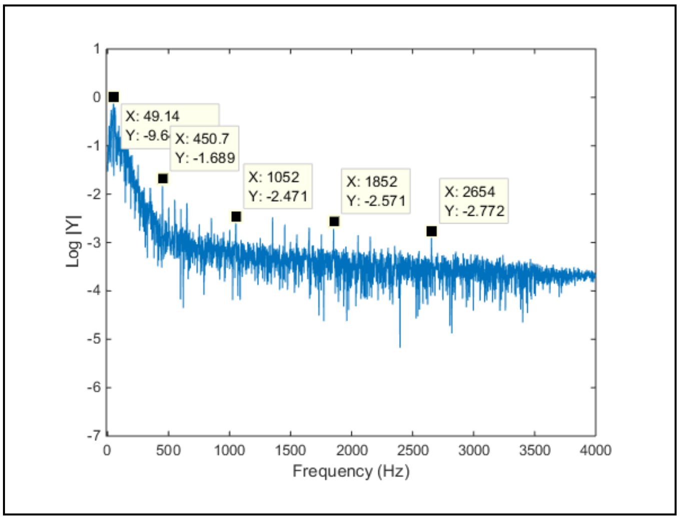

Fig. 13. FFT analysis for pipe of 500 cm length

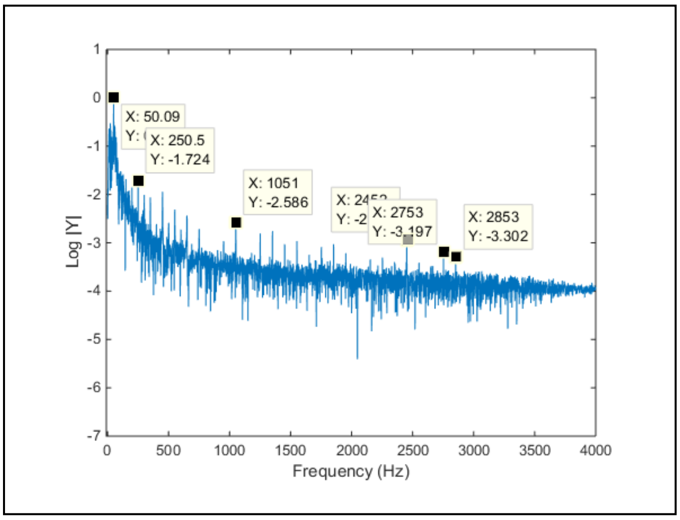

Fig. 14. FFT analysis for pipe of 600 cm length

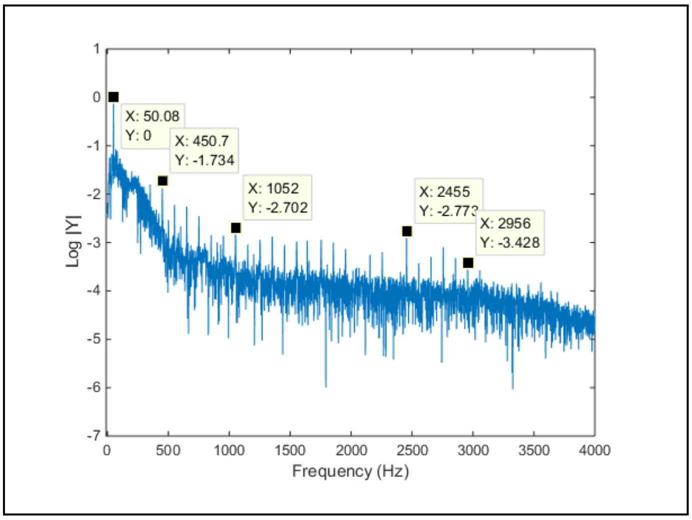

Fig. 15. FFT analysis for pipe of 760 cm length

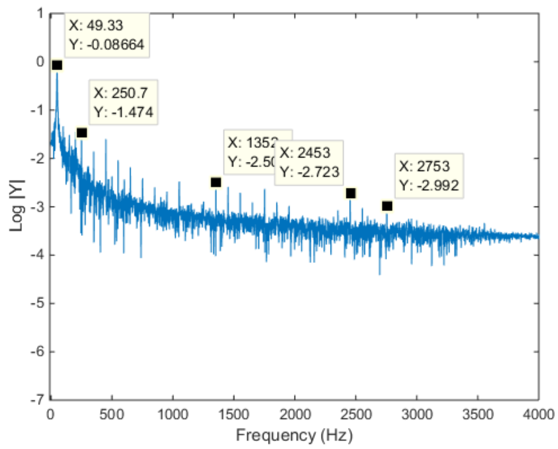

Fig. 10. FFT analysis for pipe of 1000 cm length

IV CONCLUSION

The PCG system with electronic stesthoscope has been built and from anlysis the frequency response of samples show its consistency, therefore the system is reliable and repeatable.

ACKNOWLEDGMENT *(Heading 5)*

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