Developing ECG and PCG measurement using TL064

K. Thaipakdee[1,2,*], M. Krachaechuang[1,2], P. Naiyanetr[1]
[1]Department of Biomedical Engineering, Faculty of Engineering, Mahidol University, Nakhon Pathom, Thailand
[2]These authors contribute equally to this work. *thaipakdee.kha@gmail.com

***Abstract*— On the trend of healthcare in this recent, ECG and PCG are used to detect cardiac disease likes myocardial infarction, cardiac arrythmia, and heart murmurs. Developing ECG and PCG measurement using TL064 passed filters is able to demonstrate apparently signals. 3 electrodes were handled for ECG measurement and microphone was utilized to evaluate PCG. Moreover, ECG output signal can classify signal in P Wave, PR interval, QRS complex, ST segment, and also T Wave. Similarly, PCG output signal may display clearly S1 and S2. From successful result assumes that a developing also benefit to clinical diagnose cardiac disease.**

Keywords*— *Electrocardiogram (ECG), Phonocardiogram (PCG), TL064

I. Introduction

Electrocardiogram (or ECG) showing the electrical activity of the heart is the key biosignal for supporting the clinical staff for diagnosing sickness. ECG can use to diagnose cardiac abnormalities such as cardiac arrhythmia, heart murmurs, and myocardial infarction.

Ordinarily, for the clinical purpose, ECG is used to measure the frequency in the range of 0.05 Hz and 150 Hz.

Moreover, ECG can divide into 3 components: The P wave, which happens when there are atria depolarize; the QRS complex, which delivers the depolarization of the ventricles; and the T wave, the repolarization of the signal from ventricles. The shape of wave that difference from normal ECG is able to refer some abnormal.

Phonocardiogram (or PCG) is a plot of heart sound, which created from systole and diastole of heart, opening, and closing of heart valves and the different speed of blood flow. Two sounds of heart; S1, the sound when atrioventricular valves (tricuspid and mitral) close at the outset of systole and the second, S2 when the aortic valve and pulmonary valve (semilunar valves) close at the end of systole.

In this developing, we used 3 electrodes as sensor for receive ECG, likewise, microphone was applied to collect PCG signal; passing stethoscope. After filtering the signals, we display output through oscilloscope..

II. Circuit Design

For develop ECG and PCG measurement device, we use analog filter to process input signal from electrodes and microphone respectively. The range of frequency of ECG is 0.05 Hz and 150 Hz so we use analog filter to keep only that interval and enlarge signal from 10 mV to 1 – 2 V.

A. ECG Circuits

Instrumentation amplifier circuit will eliminate the input impedance from human body and thus make the amplifier particularly suitable for use in measurement and test equipment. High-pass and low-pass filter will keep only selected interval of signal while notch filter will decrease the signal which has frequency equal to cut-off frequency.

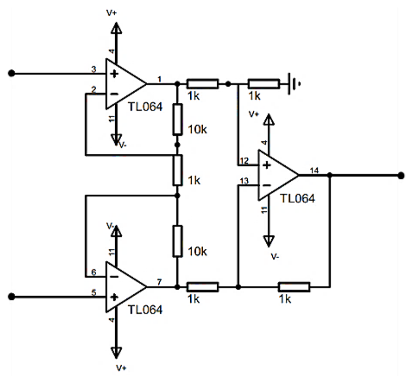

Fig. 1. Instrumentation amplifier circuit with the gain of 11

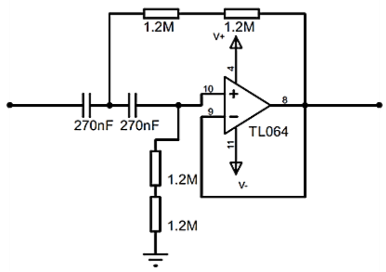

Fig. 2. Second order active high-pass filter circuit with 270nF capacitors and 2.4MΩ resistors which cut-off frequency = 0.2456 Hz

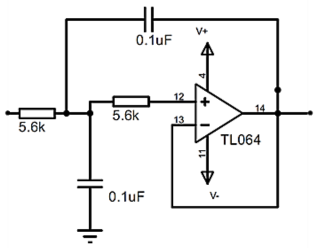

Fig. 3. Second order active low-pass filter circuit with 0.1uF capacitors and 5.6kΩ resistors which cut-off frequency = 284.205 Hz

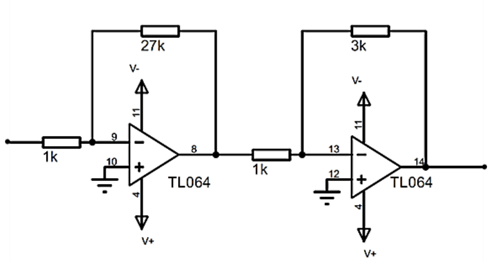

Fig. 4. Inverting amplifier circuits with gain = 27 and gain = 3

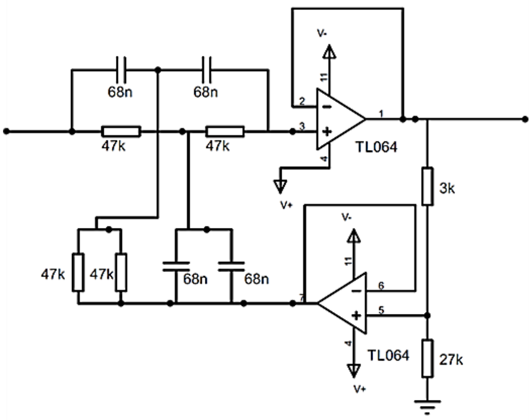

Fig. 5. Twin-T notch active filter circuit with 68nF capacitors and 47kΩ resistors which cut-off frequency = 49.798 Hz, Q = 2.5 and BW = 20 Hz

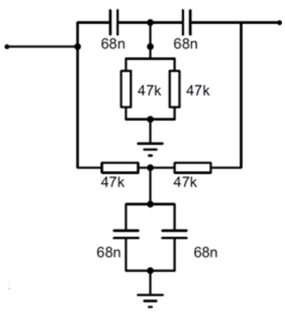

Fig. 6. Twin-T notch passive filter circuit with 68nF capacitors and 47kΩ resistors which cut-off frequency = 49.798 Hz

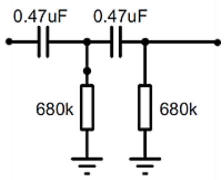

Fig. 7. Second order passive high-pass filter circuit with 0.47uF capacitors and 680kΩ resistors which cut-off frequency = 0.4979 Hz

B. *PCG Circuits*

We used band pass filter to process input of signal from microphone to analyze PCG and used condenser mic circuit to send electric to microphone in the stethoscope.

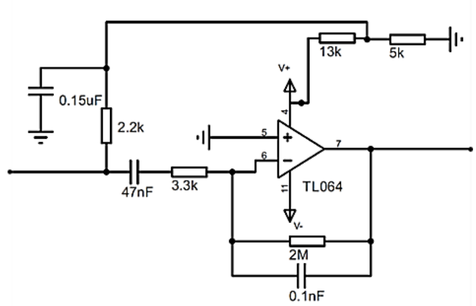

Fig. 8. Band-pass filter circuit at 102.6144 Hz and 795.7747 Hz, and gain = 606.06

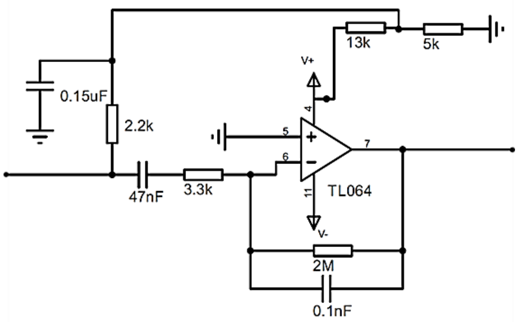

Fig. 9. Condenser mic circuit with 0.15 uF capacitor and 2.2k ohm resistor

C. *Power Supply*

Voltage divider circuit used to divide the range of voltage of electric to the device.

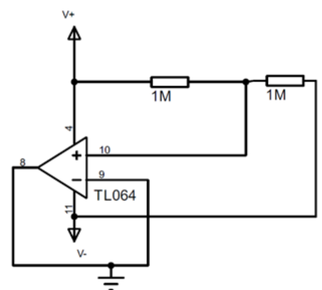

Fig. 10. Voltage Divider Circuit

III. Problems & Solutions

After we change the power supplies from using power generator to battery, harmonic of 50 Hz wave; 100 Hz, 150Hz, 200Hz was appeared and it refers to power supply-borne noise, so we added-on power supply bypassing circuit before giving power to the main circuit.

Moreover, after transferring circuits from breadboard to printed circuit board, the signals were disturbed by high frequency wave, so we connected the old circuit with second order passive low-pass filter circuit. The signals before and after annex last filter are shown in Fig. 11.

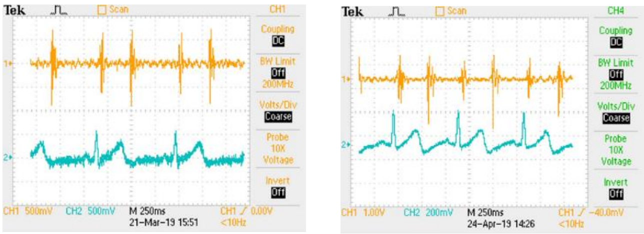

Fig. 11. Comparison of ECG and PCG signals before and after add-on second order passive low-pass filter

IV. DISCUSSION & CONCLUSION

A. *ECG Measurement.*

Bipolar lead (lead 2) was used to measure ECG while electrodes are sensor received signal. 3 electrodes were used; one assumes negative for right arm and another for left leg. In our developing, ECG passed the instrumentation amplifier circuit with the gain of 11. Further, the signal went to the second order active high pass filter circuit which cut-off frequency = 0.2456 Hz; to decrease noise from AC baseline wander. Next, it passed a second order active low pass filter circuit which cut-off frequency = 284.205 Hz because EMG noise and electrode motion artifacts have a higher frequency. Also, a signal went through the inverting amplifier circuit with gain = 27. Moreover, it passed an inverting amplifier circuit with gain = 3; for multiple 51 times of the previous signal. Furthermore, the signal also reached the Twin-T notch active filter circuit and Twin-T notch passive filter circuit in sequence. First Twin-T filter; the filter with 2 op-amps and bandwidths and another are used to remove power-line interference at 49.795 Hz. Finally, it passed the second order high-pass filter to decrease the baseline shift and ended with a second order low-pass filter before display.

B. *PCG Measurement.*

Microphone was received the signal through stethoscope. Further, voltage divider divided 2.5V from battery. In addition, condenser mic circuit made microphone worked. Next, a signal passed band-pass filter circuit at 102.6144 Hz and 795.7747 Hz, and gain = 606.06. We selected this interval to decrease the noise as in Fig. 12. Finally, it went through a second order low-pass filter before display.

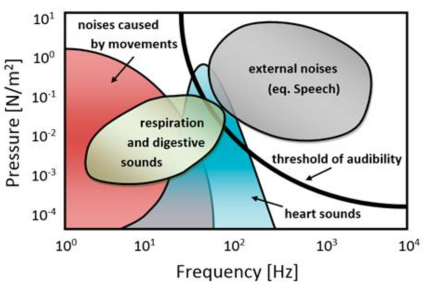

Fig. 12. Spectral intensity map of PCG and related disturbance signals

The finally output of ECG and PCG signals were shown in Fig. 13. The amplitude of signal is between 0V to 2V. After that we can sent the signal to display on computer desktop by use microcontroller, USB wire and MATLAB code.

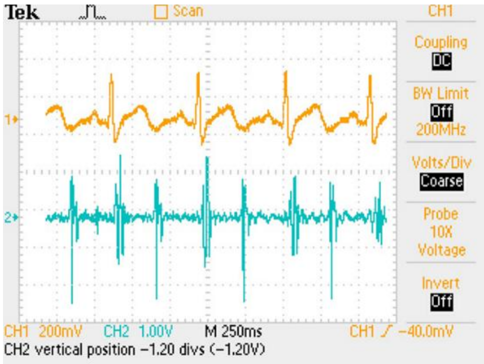

Fig. 13. ECG and PCG output

Developing ECG and PCG measurement using TL064 passed filters can display clearly signals. Moreover, ECG output signal is able to classify signal in P Wave, PR interval, QRS complex, ST segment, and also T Wave. Likewise, PCG output signal can distinguish S1 and S2. And because of those appearance refers that a developing also helps clinical officer to detect cardiac disease. Furthermore, it may be other way to improve medical device in the future

V. REFERENCES

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Circuit's Schematic