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PULSE FREQUENCY SPECTRUM OF SUBJECTS WHOSE NORMAL ELECTROCARDIOGRAM (ECG) TEST

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ABSTRACT

Pulse wave is a time domain periodic wave which the pattern is described qualitatively. Transformations is required to get the pulse wave measured quantitatively. It can be realized by using Fast Fourier Transform (FFT). That is a numerical computational method based on Fourier transform which transform the time domain periodic wave into frequency domain. Recording the pulse wave in the time domain is done on the subject of studies in which the results of the electrocardiograph (ECG) recording showed a normal heart function. Pulse wave is obtained by pressing the blood vessels using pressure sensors in the radial artery area. Pulse wave patterns in the radial artery area have a systolic time about 0.16 seconds. The special characteristic pattern of pulse wave can only be known quantitatively if the pulse wave pattern is consistent. Frequency spectrum and its constituent frequency spectrum amplitude pulse waves were obtained using the FFT method. Through this method, special characteristic of the pulse wave frequency spectrum from the subject of study was known between (1.5 to 2.1) Hz. This method is more informative because it can show special characteristics quantitatively rather than the pattern of the pulse wave in the time domain**.**

Keyword: pulse wave, the radial artery, Fast Fourier Transform (FFT), frequency spectrum.

INTRODUCTION

Pulse examinations in humans include frequency, rhythm, pulse amplitude, and the condition of the wall blood vessels [1]. Pulsesin western medicine reflects the cardiovascular system; certain diseases affect the change of pulse characteristics [2]. Pulse palpation method is one of the most important diagnostic tools. Records of the radial artery pulse in normal subjects can be seen in Figure-1.

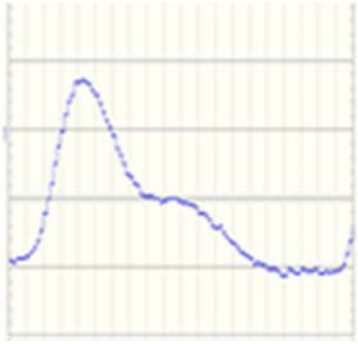

Figure-1. Radial artery pulse in normal subject.

Nowadays, the development of engineering field is growing rapidly, especially in the field of electrical engineering and signal processing. With the removal of noise interference and developments in the medical world, sensors, pattern recognition, signal processing, and database make the pulse recording tool can be realized [3].

The specific characteristic of pulse wave is very important in pulse diagnosis research. The special characteristic pulse wave based on the characteristics of the time domain can be used to determine specific characteristics pulse wave accurately [4]. However, those special features have not shown the quantitative results.

Pulse wave is a time domain periodic wave whosepattern is described qualitatively. Transformations are required to get the pulse wave measured quantitatively. It can be realized by using the Fast Fourier Transform (FFT). This method is a numerical computational method based on Fourier transform which transforms time domain periodic wave form into the frequency domain. FFT results will show the frequency spectrum and its constituent frequency spectrum amplitude pulse wave.

We proposedpulse wave subjects whose normalECG recording in time domain which reflect normal cardiac function. Furthermore, the frequency spectrums are searched by using FFT method. This method will showed the pulse wave characteristic in frequency spectrum.

METHODS

This research consists of two (2) phases Figure-2.

1. Phase I (observation phase) is pulse wave recording of the subject of research. Population targets were patients of type 2 diabetes who do not have impaired renal function with normal electrocardiograph recording results. Objects which are observed in this phase research are the pulse wave patterns of recording results in radial artery area in the time domain. Pulse wave patterns are focused in systolic

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time on the research subject.

2. Phase II is the validation phase of pulse wave recording results using FFT method. FFT method is a fast algorithm in the calculation and mathematical tools to transform the frequency domain wave in to the time domain wave. This method uses a mathematical technique that is based on the decomposition (rearrangement) of a wave to a sinusoidal wave. Signal processing uses *LabVIEW* 8.2.1 software which is created with graphical programming language. This software is developed for instrumentation that has been recognized internationally. Processing of pulse wave generates a frequency spectrum with certain amplitude, where the amplitude is the highest peak in the frequency spectrum produced. The steps in this phase of research on data recording results in radial artery are:

a) Selection of pulse wave data through *Excel software* in the form of a numeric data file (Txt) and stored as a file e.txt
b) *Filtering* process (filtering) and FFT *smoothing* (smoothing) and pulse wave pattern is stored as a file epf.txt
c) Epf.txt file opened by using *Excel software* and determine the range of time domain pulse waveform to be processed by the FFT and save it as a file epfx.txt
d) The data processing to determine the frequency spectrum and amplitude of the pulse wave frequency spectrum in the area of the radial artery are done by using *LabView 8.2.1 software*.
e) *8.2.1 LabView software* output data are displayed using *Excel software* that shows the frequency spectrum of the certain amplitude intensity which is a constituent of a pulse wave.

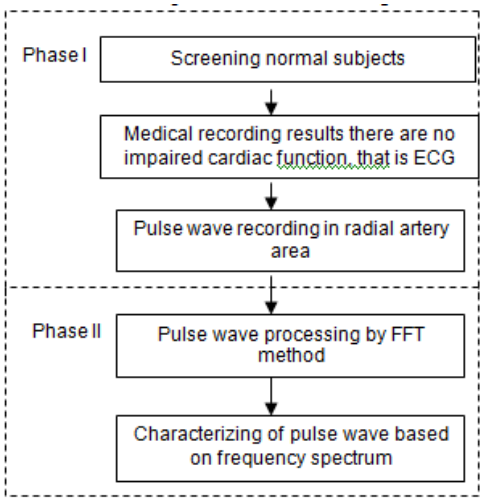

Figure-2. Flow chart of research phases.

RESULT AND DISCUSSIONS

A. Phase I

Phase I (observation phase) is pulse wave recording of the 6 subjects of research. Population targets are patients of type 2 diabetes who do not have impaired renal function with normal electrocardiograph recording results. The recoding results in the cun area of radial artery of the subjects 1 with normal ECG can be seen in Figure-3.

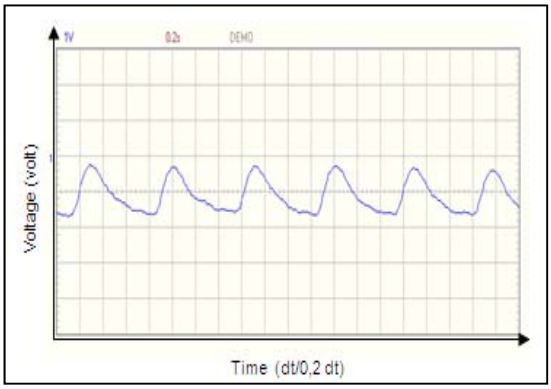

Figure-3. Pulse Wave recording ECG Normal Subject 1.

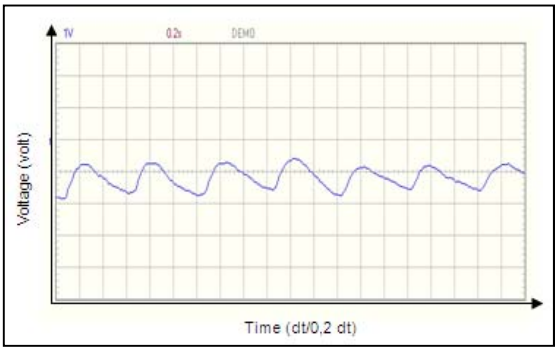

Figure-4. Pulse wave recording ECG Normal Subject 2.

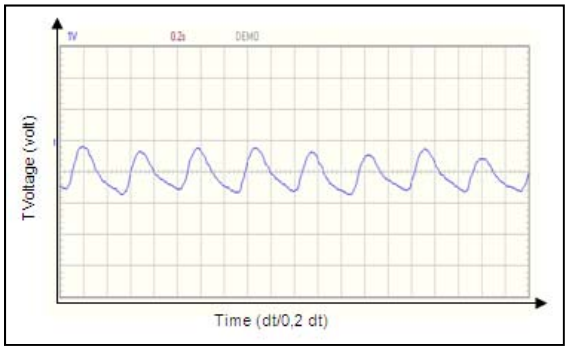

Figure-5. Pulse wave recording ECG Normal Subject 3.

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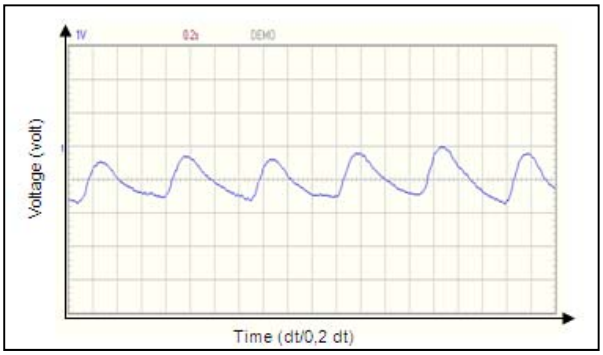

Figure-6. Pulse wave recording ECG Normal Subject 4.

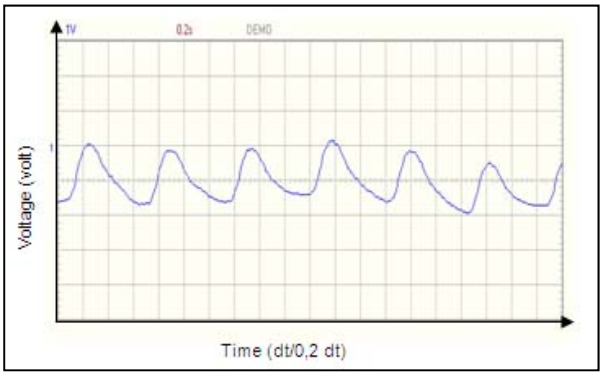

Figure-7. Pulse wave recording ECG Normal Subject 5.

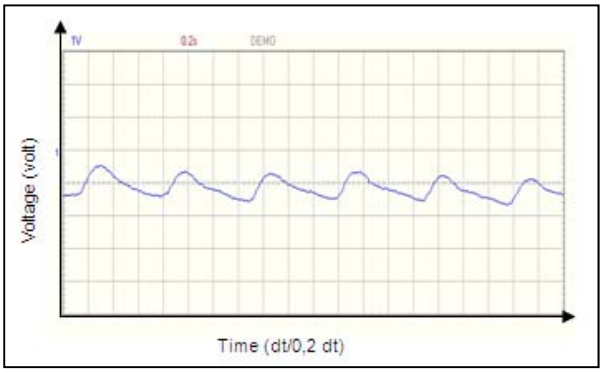

Figure-8. Pulse wave recording ECG Normal Subject 6.

Time domain pulse wave recording results provide information about amplitude, frequency, and pulse wave patterns. Observations are focused on the initial pattern of the pulse wave corresponding to the time needed to produce systolic blood pressure (systolic time) generated in the area of the radial artery. Observation of the systolic time can be seen in Table-1.

Table-1. Systolic time pulse wave in Normal Subjects.

Subject	**Systolic time** (sec)
1	0.16
2	0.16
3	0.16
4	0.16
5	0.16
6	0.16

B. Phase II

Phase II is the validation phase of pulse wave recording results by FFT method. FFT method is a fast algorithm in the calculation and mathematical tools to transform the frequency domain wave in to the time domain wave. Processing of pulse wave generates a frequency spectrum with certain amplitude, where the amplitude is the highest peak in the frequency spectrum produced.

Frequency spectrum and amplitude of the pulse wave frequency spectrum are obtained by inserting sampled data sequence *x(n)* of time domain pulse waveform by *N* sample and expressed as [5]

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-jk2\pi n/N}, k = 0,1,2,..., N-1$$

where

x (n) = a sequence of numeric data sampling results of the pulse wave time domain
X (k) = pulse wave in the frequency domain
N = number of sampling
n = number of samples from all sampling

The results of the FFT processing consisting of frequency and amplitude spectrum of subjects 1 to subjects 6 with normal ECGs can be seen in Figure-9.

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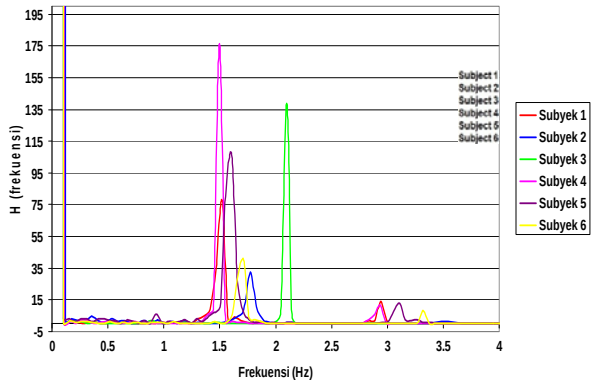

Figure-9. The result of the FFT Normal Subjects. The main frequency spectrum is a frequency distribution 2 in the range (1.5 to 2.1) Hz.

Table-1 shows that in normal subjects, the systolic time is accordance with the half time of the heart muscle contractions (0.25 to 0.3) seconds [6], which is about 0.16 seconds. This happens because the subjects do not have impaired cardiac function by ECG recordings. The special characteristic pattern of pulse wave can only be known quantitatively on the consistent pulse wave pattern. However, examination just by systolic time is not be able to provide information on the different pulse waves pattern. The pattern indicates the presence of the constituent components that have different pulse wave frequencies. Therefore, the FFT method is used to determine the frequency spectrum and the ratio of the pulse wave amplitude constituent.

Based on Figure-9, it can be seen that the frequency spectrum of the primary frequency which is frequency distribution 2 of subjects with normal ECG in the range (1.5 to 2.1) Hz. The special characteristic of pulse wave that are obtained by the FFT method is more informative than the time domain pulse wave pattern. The FFT results can be demonstrated specific characteristics quantitatively which is the range of the frequency spectrum in subjects with normal ECG.

CONCLUSIONS

Pulse wave patterns in the radial artery area have systolic time about 0.16 seconds. The special characteristic pattern of pulse wave can only be known quantitatively on the consistent the pulse wave pattern. The main frequency spectrum subjects in normal ECG is the frequency distribution of 2 in the range of 1.5 to 2.1 Hz. The special characteristic of pulse wave that are obtained by the FFT method is more informative than the time domain pulse wave pattern. The FFT results can be demonstrated specific characteristics quantitatively which is the range of the frequency spectrum in subjects with normal ECG.

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