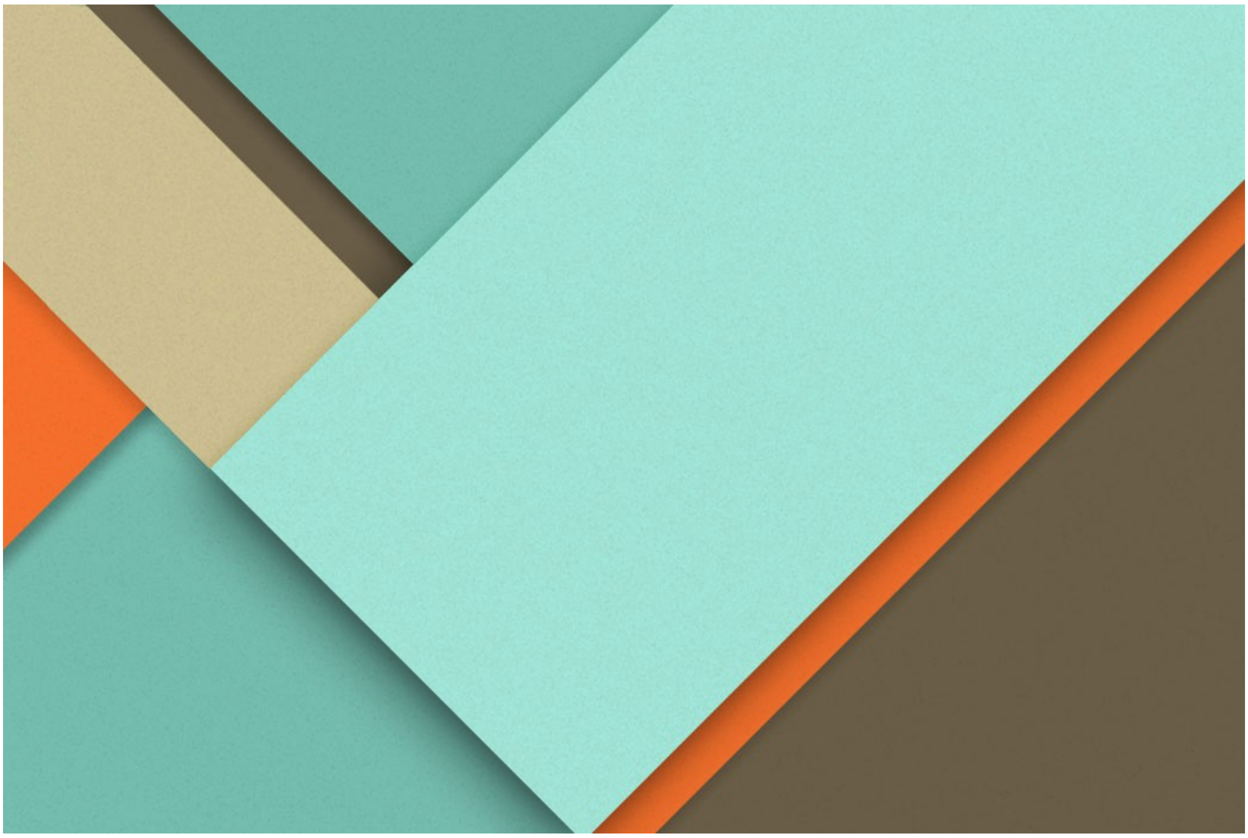

Signals And Systems Project

10.03.2022

Team Number - 07

Team Member - 1

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Team Member - 2

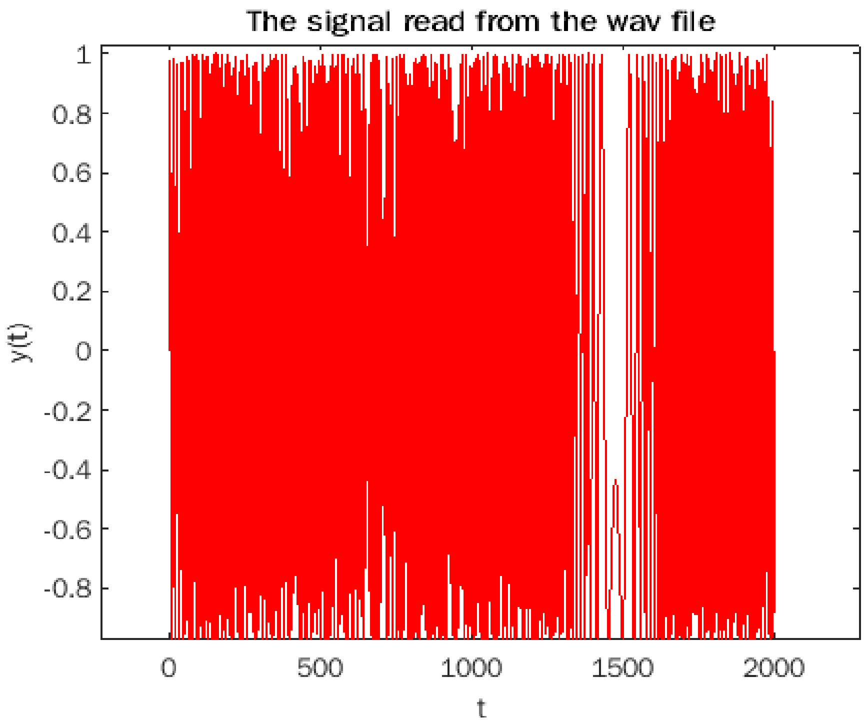
% NIPUN GOYAL <2021102029> %

Task - 1

Part (b)

signal and characterstics

% Signal visualised by me is given below :-



% The signal given above is a sinusoidal wave curve . This thing can be verified by Zooming yhe curve and visualising it.

The given is somehow of the form:-

Y = (A)*SIN(wt + $).

A : Amplitude of the Sin wave

w : Angular frequency of the signal

{

w = 2*pi*f*t (where f is a variable quantity)

}

$: Initial phase

t : Time

The reason that this signal is sinusoidal is that it can be clearly visualised by focusing on plot at **time = 1400 to time = 1600** where **frequency (that is**

variable) has reached an exceptionally small value . Hence at that point of time it can be easily seen that the nature of the plot is sinusoidal.

NOTE - These kind of signals are majorly used in FM radio signals, radar and television signals.

% Characterstics of signal are as follows :-

1. This is Sinusoidal plot containing 2000 sample discrete time points.

2. The Maximum value curve ever attained is : 1.

3. The Minimum value curve ever attained is : -1.

4. Frequency of signal is variable.

(Major characterstics of signal related to frequency are placed in spectrogram portion of the report)

5. Beacuse **(Wavelength=velocity/frequency)**. Hence Wavelength is also variable.

6. **Initial Phase ($) of the signal is 0** which can be directly verified by visualising of the plot at x=0.

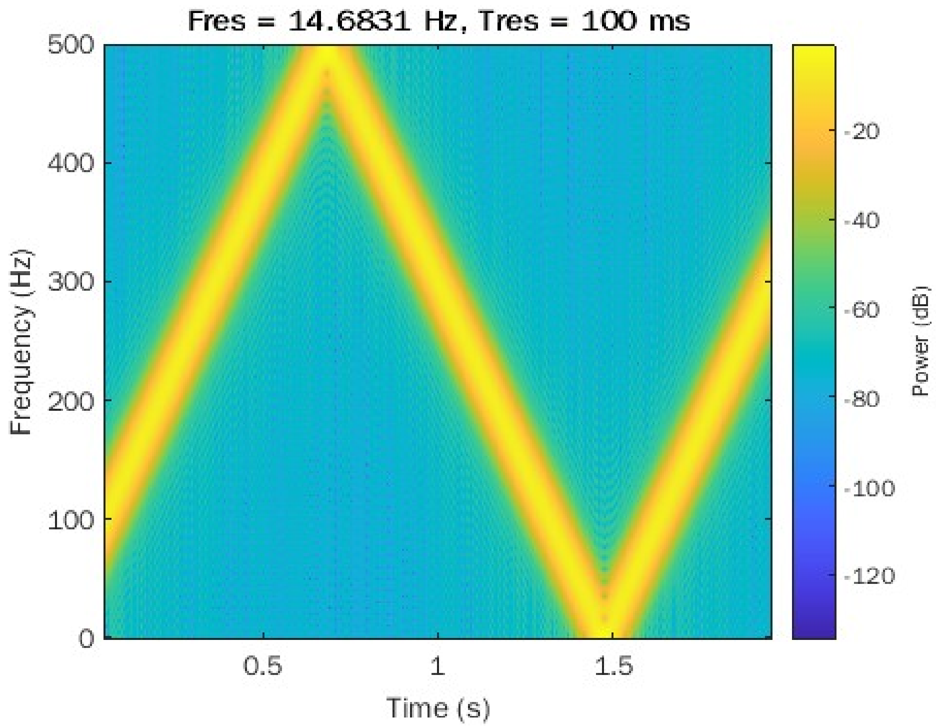
7. Y = A * Sin(wt + $)

i) Mean of Y is : **-0.01784**

ii) Median of Y is : **-0.03305**

iii) Mode of Y is : **0.809**

spectrogram



<u>% Properties of above spectrogram are as follows :-</u>

1. A spectrogram is plot of frequency versus time of a signal.
2. The frequency of this Signal is not constant.
3. Frequency is following a ZIG-ZAG pattern.
4. Initially frequency was 100 Hz.
5. Maximum Frequency reached is : 500 Hz
6. Minimum Frequency reached is : 0 Hz at time=1.5 s.
7. Frequency is initially increasing for some time after that is reaches its peak and starts decreasing and again reaches the peak and againg starts increasing.
8. This kind of frequency is highly used in FM radios.

Part (c)

Frequencies

%

F0 = 70 Hz

F1 = 700 Hz

%

In this part of project we needed to plot a signal similar to the plot provided in previous part but using the frequencies **from 70 Hz to 700 Hz.**

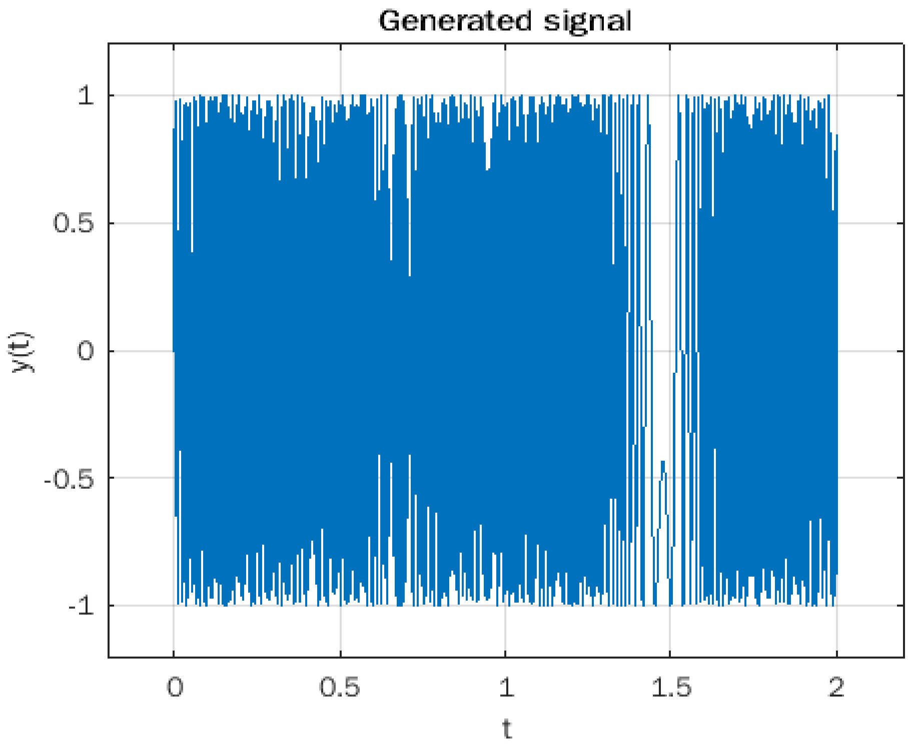
F0 and F1 are limiting frequencies of the new signal that bounds the frequency of the generated signal.

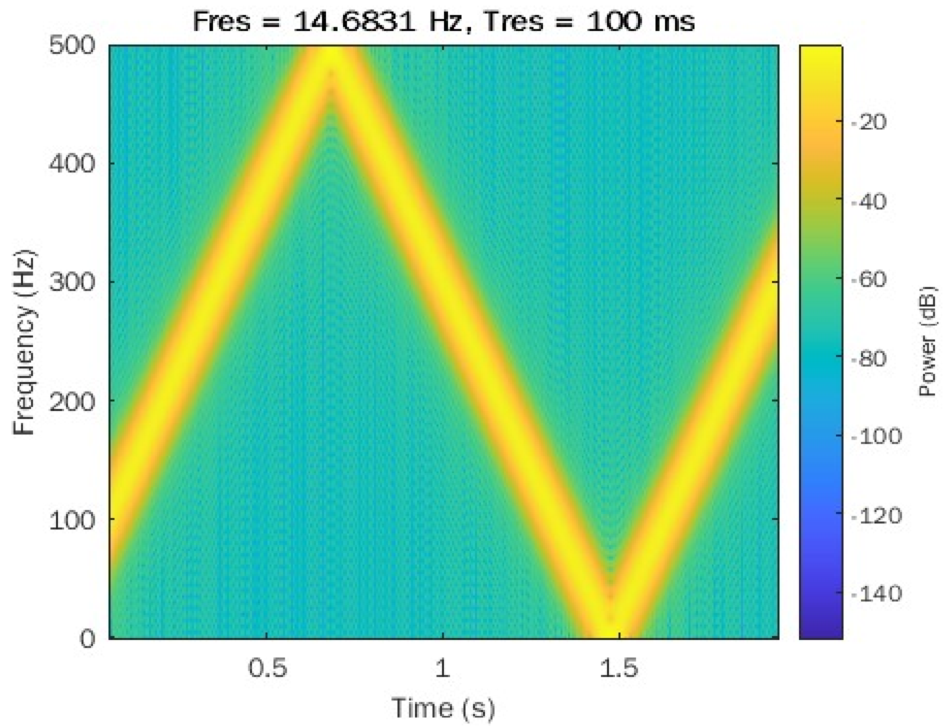
As we increase the frequency of the signal the signal becomes more and more dense and vice versa if we decrease the frequency.

Hence in some sense F0 and F1 also plays a role in determining how dense the signal must be.

Any change in frequency further can be visualised by ploting a spectrogram of the signal.

%

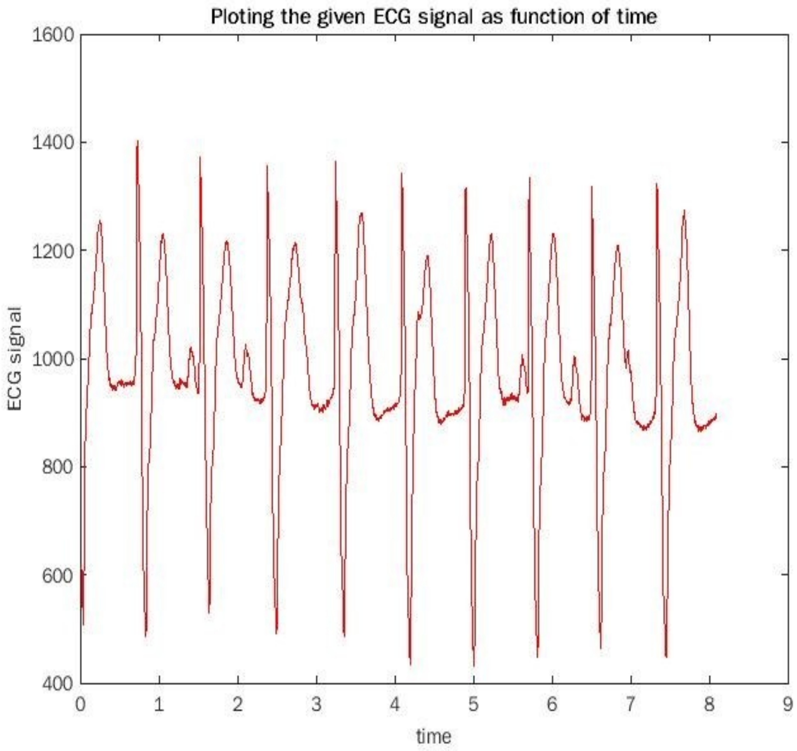

Generated signal
1
0.5
0
-0.5
-1
y(t)
0
0.5
1
1.5
2
t


Fres = 14.6831 Hz, Tres = 100 ms
500
400
300
200
100
0
Frequency (Hz)
0.5
1
1.5
Time (s)
-20
-40
-60
-80
-100
-120
-140
Power (dB)

Task – 2

Part(b)

Plotting the ECG Signal:



%Quasi-Periodic and Sampling Rate:

Quasi-Periodic are those signals which are approximately periodic.
From the plot shown above we can conclude that the signal must be Quasi-Periodic, as the peaks come at a regular interval of time.
Ts (Sampling Rate) is time difference between any two consecutive points which are used to form the given signal.
In file named **107annotions.txt** we are given with timestamps of few samples, using this we calculate the Ts value.
Sample 47 is taken at time = 0:00.131.
Since the samples are starting from 0, the **Ts comes out to be = 0.131/48 ~ 0.0027sec.**
Therefore the 3000th sample will come on time = 3000*Ts = 8.1 seconds.
The approximate period of the signal is: 0.8316 seconds.

Or by using the sampling data we can see that the signal repeats after 308 samples.
So, the approximate period of the ECG signal = 308*Ts = 0.8316 seconds.

Part(c)

Design of LTI System:

We must design an LTI system which gives output signal with peaks with same period as the original input signal.
LTI SYSTEM:

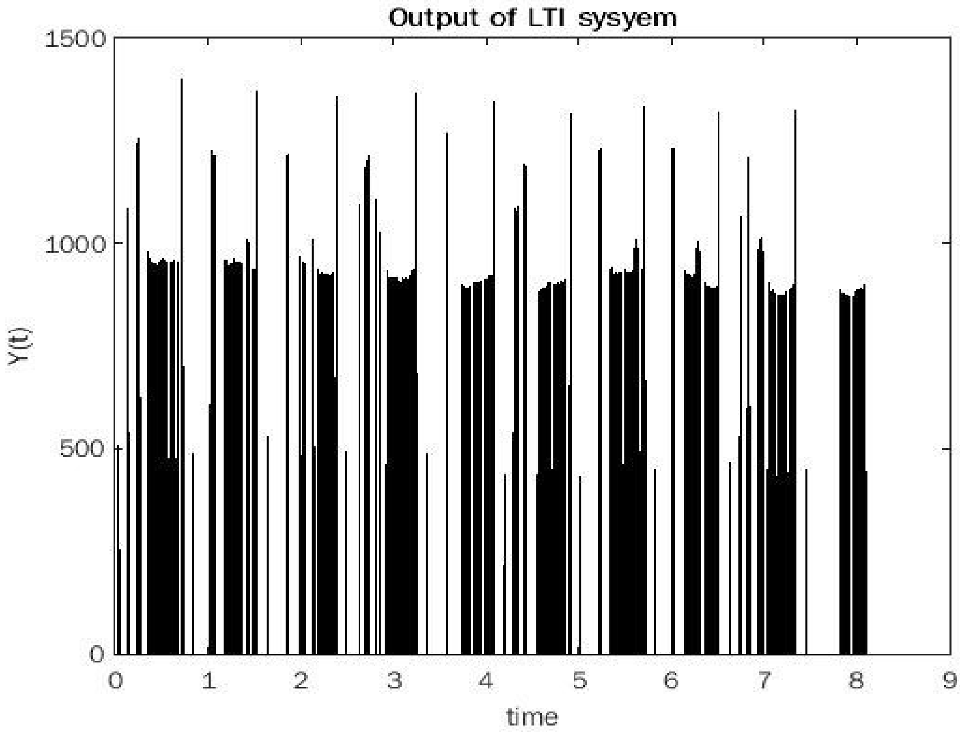
$$U\left[\frac{\left|\{x(T)-x(T-T_s)\}\cdot\{x(T)-x(T+T_s)\}\right|}{\{x(T)-x(T-T_s)\}\cdot\{x(T)-x(T+T_s)\}}\right]\cdot x(T)$$

SYSTEM RESPONSE OF LTI SYSTEM:

$$U\left[\frac{\left|\{\delta(T)-\delta(T-T_s)\}\cdot\{\delta(T)-\delta(T+T_s)\}\right|}{\{\delta(T)-\delta(T-T_s)\}\cdot\{\delta(T)-\delta(T+T_s)\}}\right]\cdot \delta(T)$$

This would be our LTI system which copies the values of the peaks of input signal (Here peak refers to maxima and minima of the input signal).
At time T in input signal, if there is a peak the output signal has a line parallel to y-axis at that time whose **length is equal to amplitude of the peak**. If in input signal at time T there is no peak the output signal will have value zero at that point.
If there is a peak, then the product [X(T)-X (T - Ts)] * [X(T)-X (T + Ts)] will be always positive.

Output of LTI system for ECG signal as input:



Reasoning and Period Estimation:

Reasons for choosing this system are:

1.Using the output of the system our primary aim is to find the period of the signal, period of the signal can be calculated by taking the time difference between two consecutive same length peaks.

2.Now for taking the difference between two consecutive same length peaks we must build output signal which contains only peaks. Therefore, we designed the above LTI system.

How to identify the period of input signal using the LTI system and its output? For this we just take the difference of time of the longest and consecutive peaks of the output signal, this time difference is the period of the input signal. Which turns out to be a time difference between the first 2 highest peaks located at time 0.7263 sec and 1.5282 sec. **Therefore, period of the signal is 1.5282 - 0.7263 = 0.8019 sec.**

If we think of calculating period using next two highest peaks it comes out to be 0.8532 sec.

Using the next two pics it turns out to be 0.8667 sec.

Therefore, taking the average value of period: 0.837 seconds.
% This choice is not unique. %

Part(d)

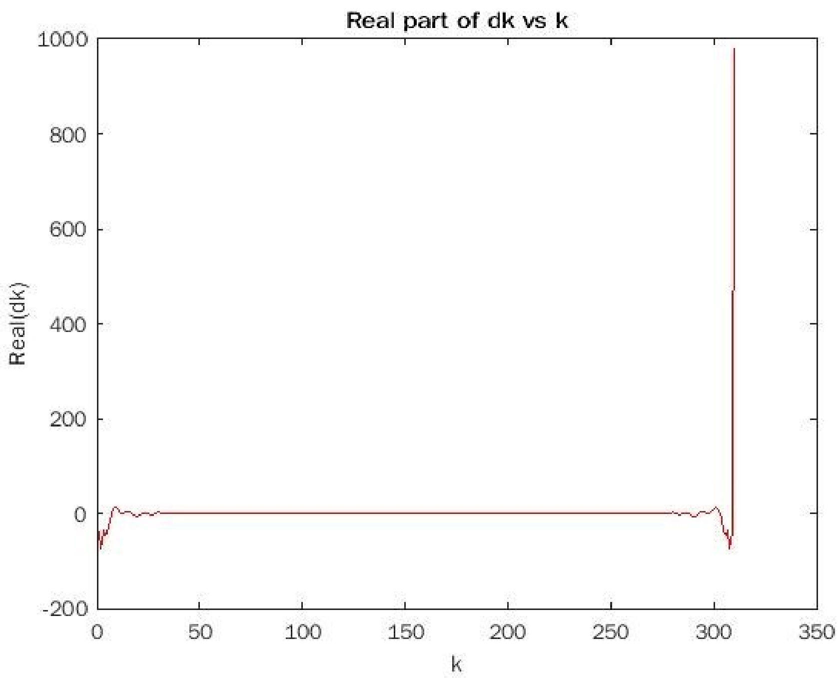
Fourier Series Analysis:

Fourier series analysis includes finding dk vs k, we find dk using formula:

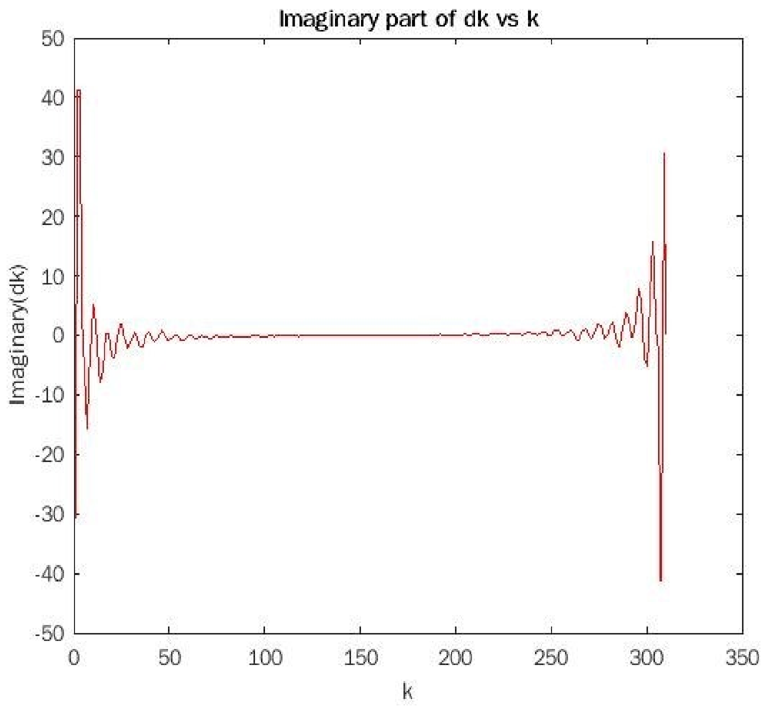
dk = I/N (**summation of x[n]*e^(-j*k*w0*n) where n ranges from 0 to N-1**).
Here N represents the number of samples in one period of given input signal.
Which is equal to the average time-period / ts .
N = 0.837 / 0.0027 = 310.

Plots:

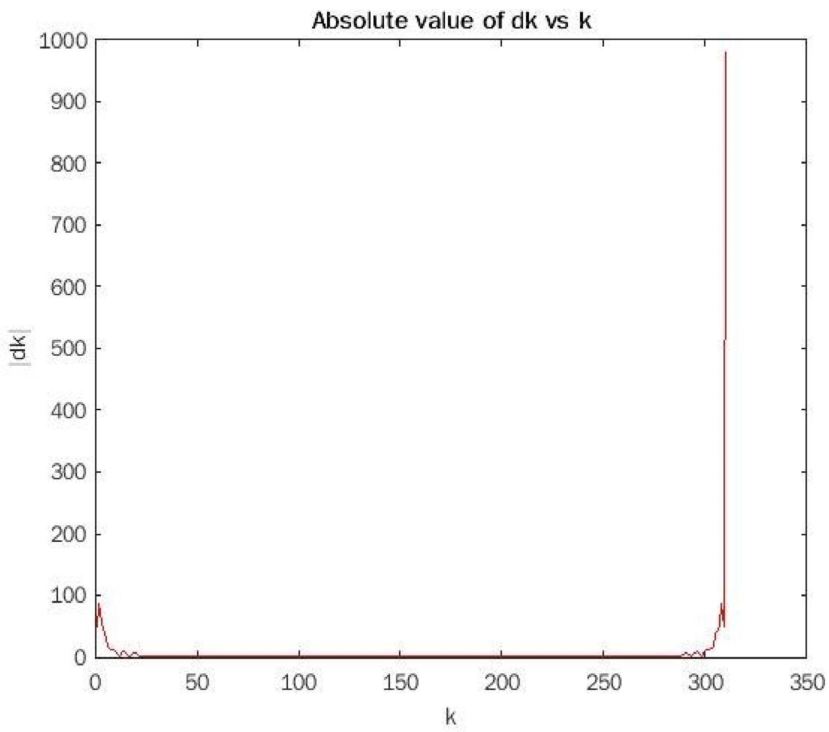
1.Real part of dk vs k:



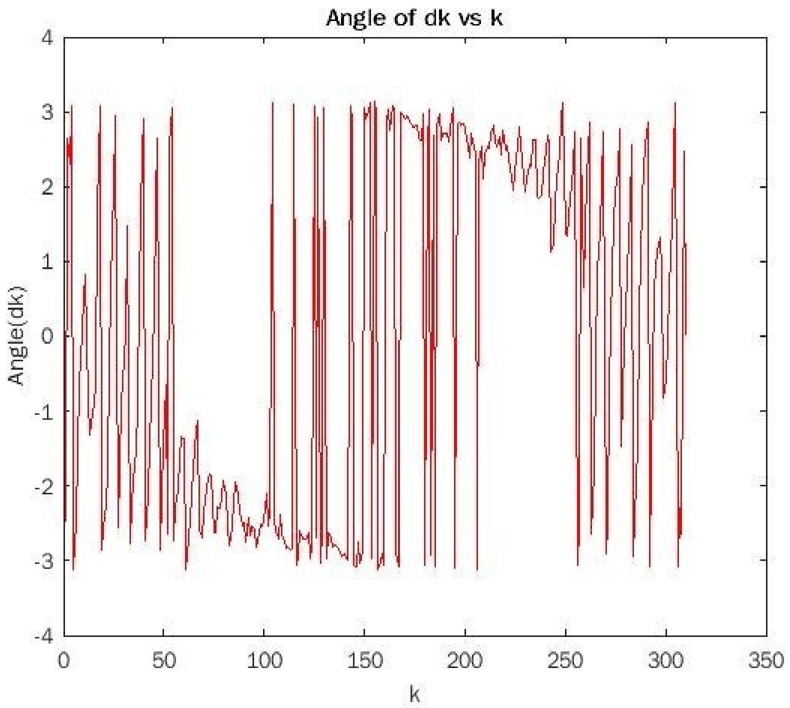
2.Imaginary part of dk vs k:



3.Absolute value of dk vs k:

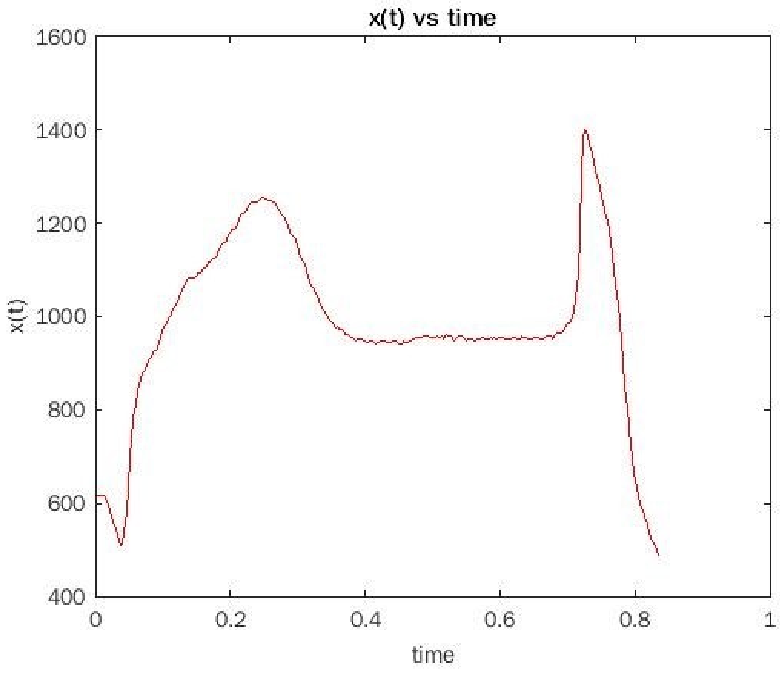


4. Angle of dk vs k:



Generating Synthetic ECG Signal:

We can synthesize ECG signal by using the mentioned formulla:
X[n] = summation of dk*e^(i*k*w0 *n) where k ranges from 0 to N-1.
If we build the same signal N remains = 310, and for this signal we also know the required values of dk.
Therefore, we can create a single period of the same ECG signal using the calculated values of dk.
The plot of the created graph is shown below, and it matches with our original input signal.
We know the relation between n and time so instead of ploting graph with x axis as n, we can directly plot it against x axis as time.



x(t) vs time
1600
1400
1200
1000
800
600
400
x(t)
0
0.2
0.4
0.6
0.8
1
time