Signal Processing of Biosignatures ENG4191 and ENG5291

Assignment 1

Exercise 1:

Calculate Discrete Fourier transformation and inverse Fourier transformation using the following Matlab code. Provide figures in your report.

```
Fs = 1000;                    % Sampling frequency
T = 1/Fs;                     % Sample time
L = 1000;                     % Length of signal
t = (0:L-1)*T;                % Time vector
k=L/Fs                        %Scaling factor for inverse FFT

% Sum of a 50 Hz sinusoid and a 120 Hz sinusoid
x = 0.7*sin(2*pi*50*t) + sin(2*pi*120*t);
y = x + 2*randn(size(t));     % Sinusoids plus noise

figure
plot(Fs*t(1:50),y(1:50))
title('Signal Corrupted with Zero-Mean Random Noise')
xlabel('time (milliseconds)')

%%Calcuate FFT
Y=fft(y,L)/L;
f=Fs/2*linspace(0,1,L/2+1);
figure
plot(f,2*abs(Y(1:L/2+1)))
 title('Single-Sided Amplitude Spectrum of y(t)')
xlabel('Frequency (Hz)')
ylabel('|Y(f)|')

%Calculate IFFT
y1=k*real(ifft(Y))*Fs;
figure
plot(Fs*t(1:50),y1(1:50))
title('Reconstruction of the Signal Corrupted with Zero-Mean Random Noise')
xlabel('time (milliseconds)')
```

What happens with FFT when Fs=500? Why? Does it affect location of peaks in IFFT? [0.5]

What happens with FFT when Fs=110? Why? [0.5]

Now add lines

```
figure
plot(abs(Y))
```

What do you see? Why does it look different then in the previous case? [0.5]

Exercise 2

Expand the following z transform as power series of z-1, and write down their first five sample values starting from n=0 [1]

$$X(z) = \frac{(z+1)}{(z-1)}$$

Reminder: Power series $\sum_{n=0}^{\infty}\left(\frac{a}{z}\right)^n = \frac{1}{1-\frac{a}{z}} = \frac{1}{1-az^{-1}}$

Hint: apply principle of linearity

Exercise 3

Using Matlab functions 'fdesign' and 'design', create the following filters (do not forget to create an m file to write a script that should be printed in your report). [0.5] a-c each

(a) Low pass Hamming and low pass Hann filters, with cut off frequency Fc=300 Hz, sampling frequency Fs=2000 Hz, filter order N=100. Plot both filters on the same graph and use legend in the figure to mark each filter. Comment on the figure.
(b) Low pass Hamming filter and high pass Hamming filter with same specifications as in (a). Create a new figure and plot both filters on the same figure. Comment on the figure.
(c) Band pass Hamming with cut off frequencies Fc1=200 Hz, Fc2=400, N=100, sampling frequency Fs=2KHz; Band pass Hamming with cut off frequencies Fc1=200 Hz, Fc2=400, N=50, sampling frequency Fs=2KHz. Create a figure with both filters. Comment on the figure.

Exercise 4

Calculate corresponding normalised frequencies

(a) For a band pass filter 8-12 Hz, sampling frequency 1KHz [0.5]
(b) For a band pass filter 8-12 Hz, sampling frequency 500 Hz [0.5]