6.s02: EECS II - From A Medical Perspective

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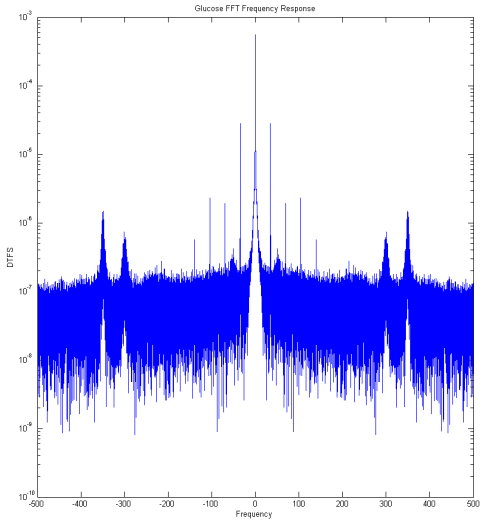
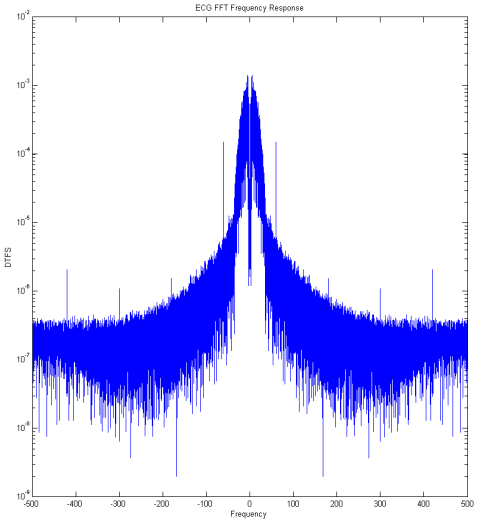
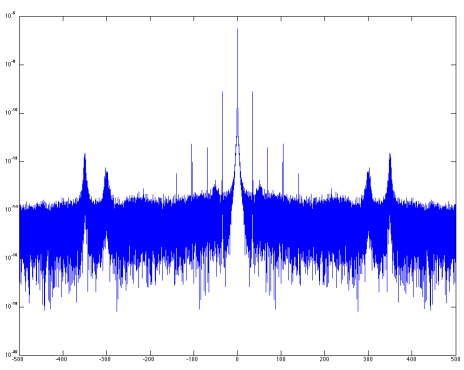
1. (a) Frequency spectrum of glucose and ECG signals.

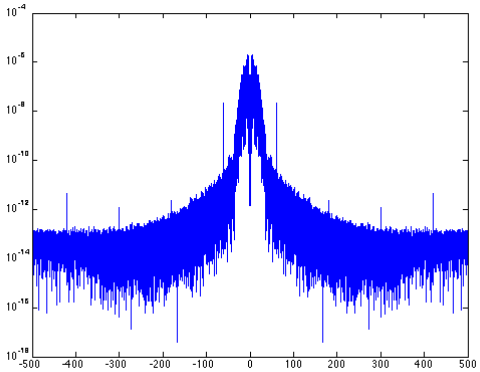





```
N = length(xg0);

xg0fftUnshifted = fft(xg0)/N;
xe0fftUnshifted = fft(xe0)/N;

xg0fft = fftshift(xg0fftUnshifted);
xe0fft = fftshift(xe0fftUnshifted);

f = linspace(-500, 500*(1-1/N), N);

semilogy(f, abs(xg0fft));
xlabel('Frequency');
ylabel('DTFS');
title('Glucose FFT Frequency Response');

semilogy(f, abs(xe0fft));
xlabel('Frequency');
ylabel('DTFS');
title('ECG FFT Frequency Response');
```

(b) Energy spectral density of glucose and ECG signals.





```
% Using variables defined in (1a)
xg0s = abs(xg0fftUnshifted).^2;
xg0sfft = fftshift(xg0s);
semilogy(f, xg0sfft);

xe0s = abs(xe0fftUnshifted).^2;
xe0sfft = fftshift(xe0s);
semilogy(f, xe0sfft);
```

(c)

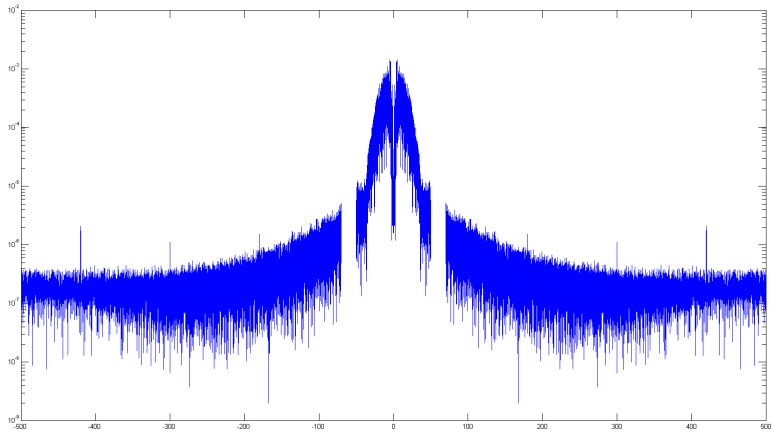
Glucose	1	5	100	500
E_T	0.0850	0.0850	0.0850	0.0850
$E(f_1, f_2)$	2.0e-04	8.1e-05	1.77e-05	1.0e-11
Ratio	0.0024	9.6e-04	2.09e-04	1.2e-10

ECG	1	5	100	500
E_T	21.622	21.622	21.622	21.622
$E(f_1, f_2)$	10.810	8.4107	1.7e-04	2.6e-09
Ratio	0.5000	0.3890	7.9e-06	1.2e-10

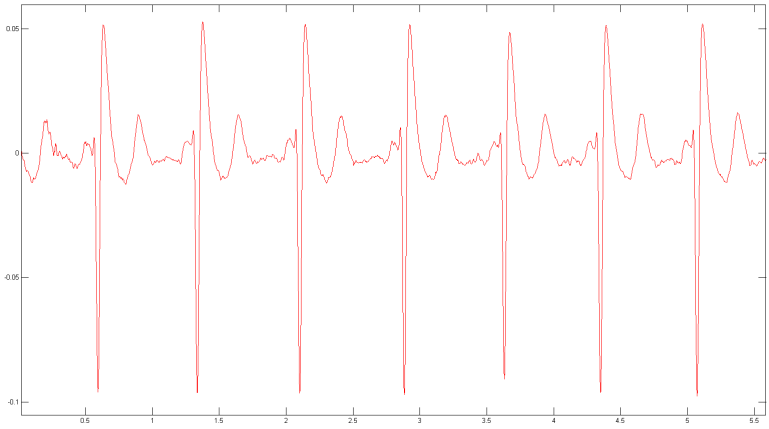
```
% Using variables defined in (1a) and (1b)
f1 = 500;
f2 = 500;

k1 = N*f1 / 1000;
k2 = N*f2 / 1000;

EtG = N * sum(xg0s);
EfG = N * sum(xg0sfft(floor(k1+(N-1)/2):floor(k2+(N-1)/2)));
GlucoseRatio = EfG / EtG;

EtE = N * sum(xe0s);
EfE = N * sum(xe0sfft(floor(k1+(N-1)/2):floor(k2+(N-1)/2)));
ECGRatio = EfE / EtE;
```

(d) The noise in the glucose signals appears to be greater than the noise in the ECG signal. This is because the target frequencies in the glucose signal are the low frequencies, so we are interested in the changes over a long period of time. The high frequency components are correctly attributed to noise in the signal. The ECG, on the other hand, features high frequency characteristics that are not noise, which means that this technique does not reveal a lot about the signal quality.

2. Fourier coefficients of notch filter



Filtered ECG signal

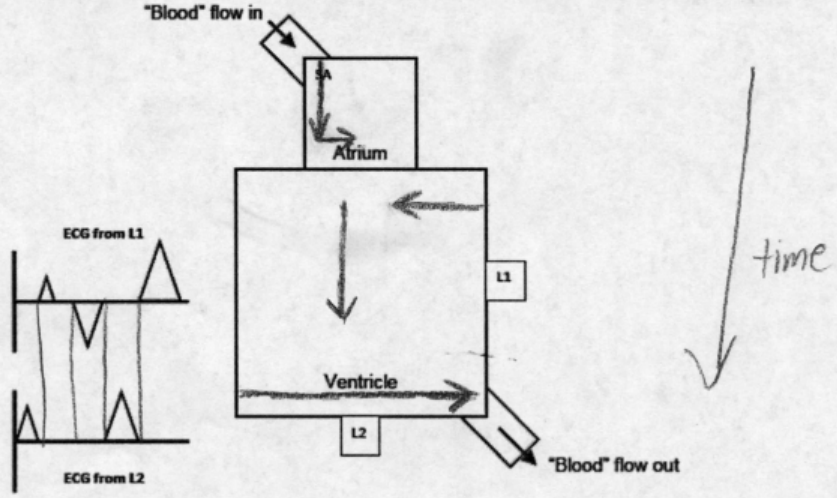


```
function H0 = notchFilter(N, lowFrequency, highFrequency)
    middle = N/2;
    lowK = 60 * lowFrequency;
    highK = 60 * highFrequency;
    H0 = ones(N,1);
    H0(middle-highK:middle-lowK) = 0;
    H0(middle+lowK:middle+highK) = 0;
end

N = length(xe0);
xe0fftUnshifted = fft(xe0)/N;
xe0fft = fftshift(xe0fftUnshifted);
H0 = notchFilter(N, 50, 70);
xe0Filtered = ifft(ifftshift(H0 .* xe0fft))*N;
```

3.

Problem 3 (5pts): Alien ECG

An alien life form was on his way to a Black Sabbath concert in Boston when it suddenly felt its heart racing. In order to get a diagnosis, you decide to acquire its ECG. To know what to expect, you look up the Alien's anatomy. It turns out that the alien's heart has only 1 atrium and 1 ventricle as shown



You attach electrodes to the alien so that you record the voltage in two leads: L1 and L2 (Don't worry about how many electrodes you are using and where they are located on the alien's body. The important thing to remember is that current that moves in the direction of L1 leads to a positive deflection and the same is true of current that heads in the direction of L2.)

On the diagram above, draw the depolarization circuit for the alien heart.