Assignment 5

Objective – In this assignment, we were asked to implement the problem 8.1 from Biosignal and medical image processing book by Semmlow which constitutes of Weiner-Hopf problem. Our motive was to generate a cosine signal of our choice and add a white gaussian noise to it, thus making a noise consisting signal with SNR = -8dB. After generating the noisy signal, we had to implement Weiner-Hopf equation to build an optimal filter to filter out the noise and reconstruct the original signal.

Learning objective – This assignment concentrates on couple of factors:

1. The performance of the optimal filter achieved by implementing Weiner-Hopf equation.
2. The relation between signal-to-noise ratio and variance.

Task 1: Signal Generation

First task was to generate cosine signal. I generated two cosine signals one with dc offset and other without dc offset and added both the signals. Both signals are varying with time and have different frequencies.

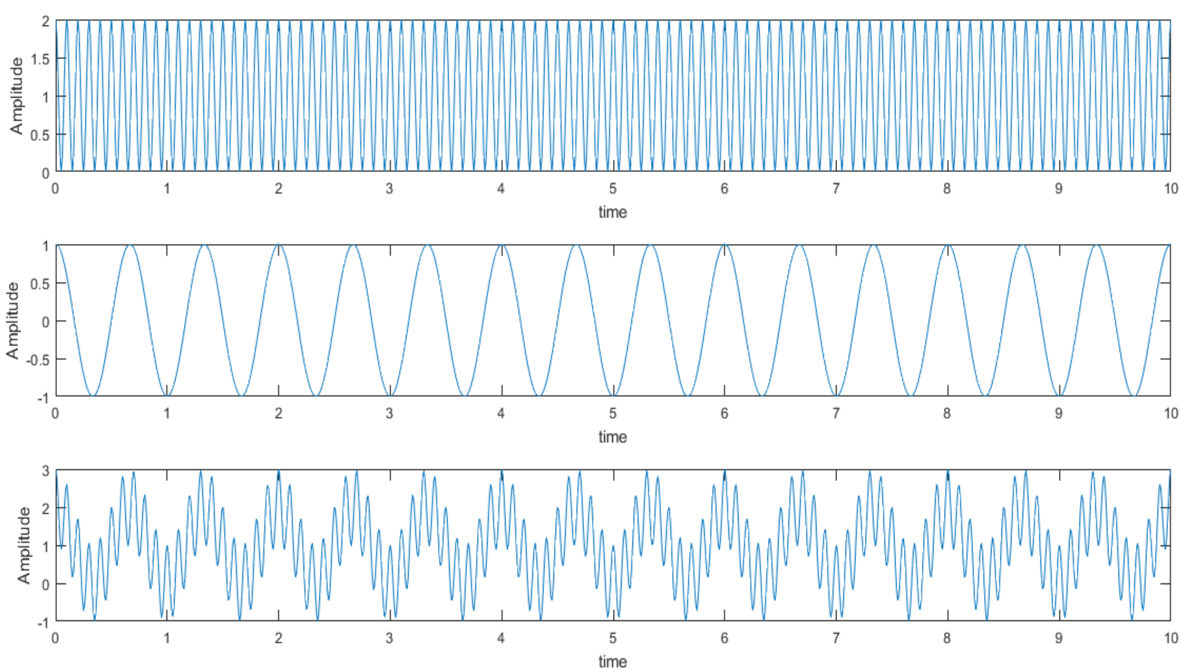

Fig 1: Generated signals

Generated signals were as expected. There was a modulation that took place where the lower frequency signal was carried by higher frequency signal.

Task 2: Noise Generation

Secondly, we had to generate noise and add it to the cosine signal such that SNR of the noisy signal = -8dB. To achieve this,

1. Original signal power was calculated using norm and converted into log scale. The value came around 3dB.
2. As SNR is the ratio of signal and noise, in logarithmic scale it will be simple subtraction. Thus, we found out that the noise power in log scale will be approximately 11dB.
3. After that we had to generate the noise signal with randn function in matlab. Now randn generates normal distribution values and hence, have a mean of 0. Thus, as power is defined as square root of Euclidean norm of the signal, power is equal to the variance of the signal.
4. Thus, we multiplied the randn signal with the square root of the variance to achieve power close to 11dB.

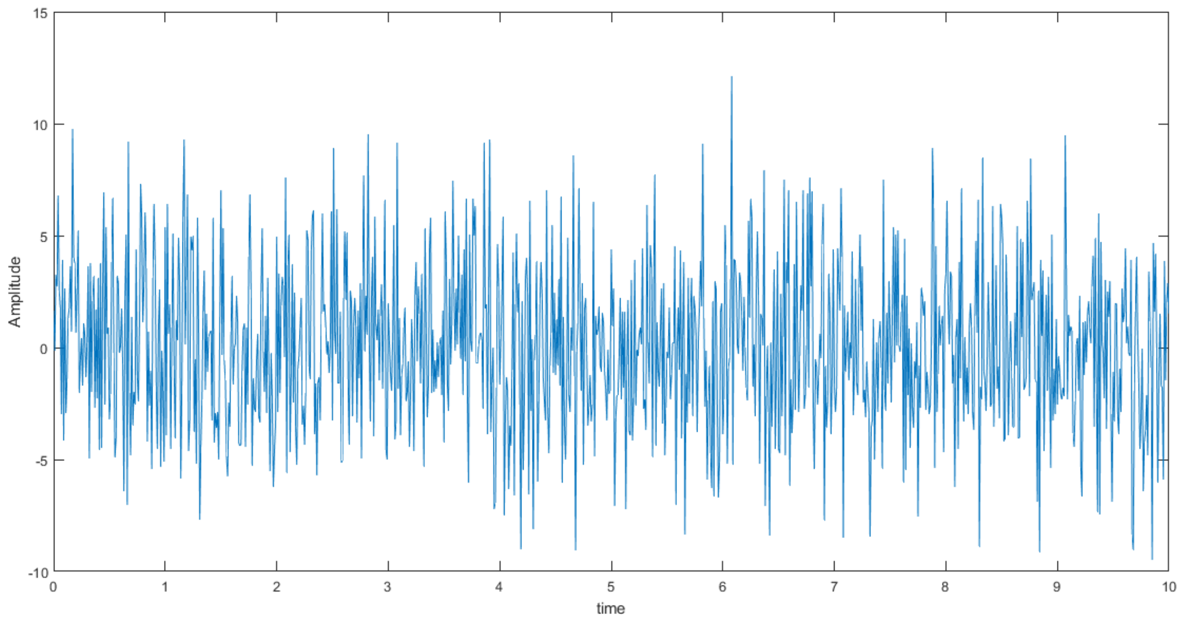

Fig 2: Noise

Task 3: Noisy Signal Generation

Task 3 was to add the noise to the original signal and obtain SNR of -8dB. With the method mentioned above, I obtained SNR values ranging from -7 to -10 dB. I believe, this is because of the changing values from the randn signal.

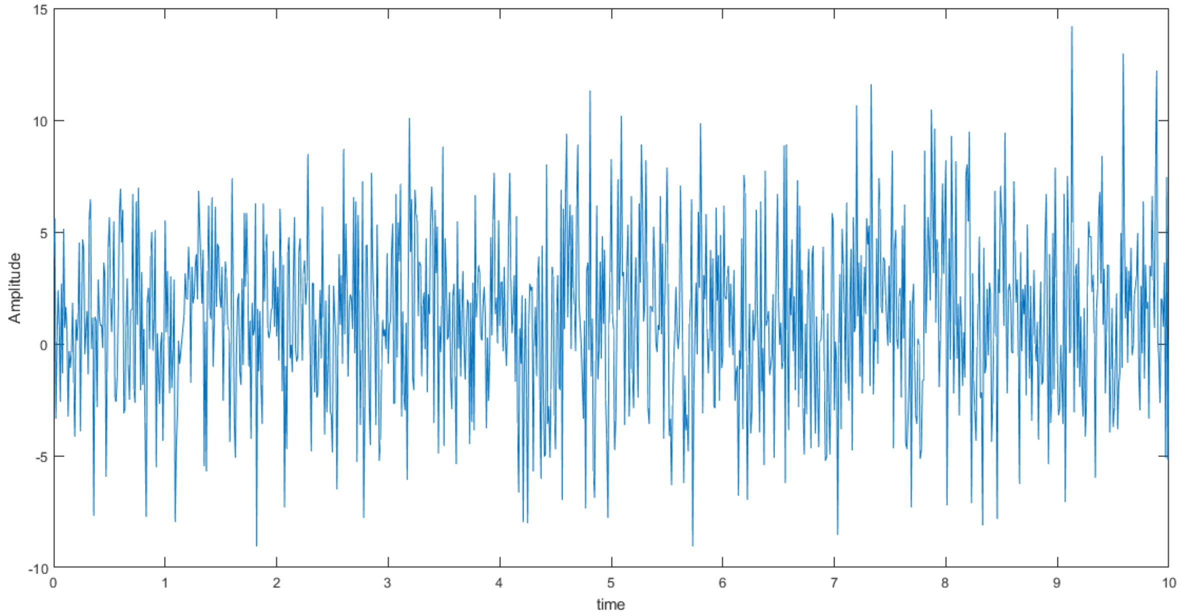

Fig 4: Noisy Signal

I expected the snr to be close to -8. Well, it is close but it's ranging from -6 to -10 dB. I didn't expect so much variation. Also, I observed the varying power is due to randn function where different values are generated. I expected as the noise is zero mean and variance value is fixed, we can construct signal with -8dB power.

Task 4: Reconstructed output

It was to reconstruct the original signal x from noisy signal xn using Weiner-Hopf equation. Filter was implemented using the reference code from the book.

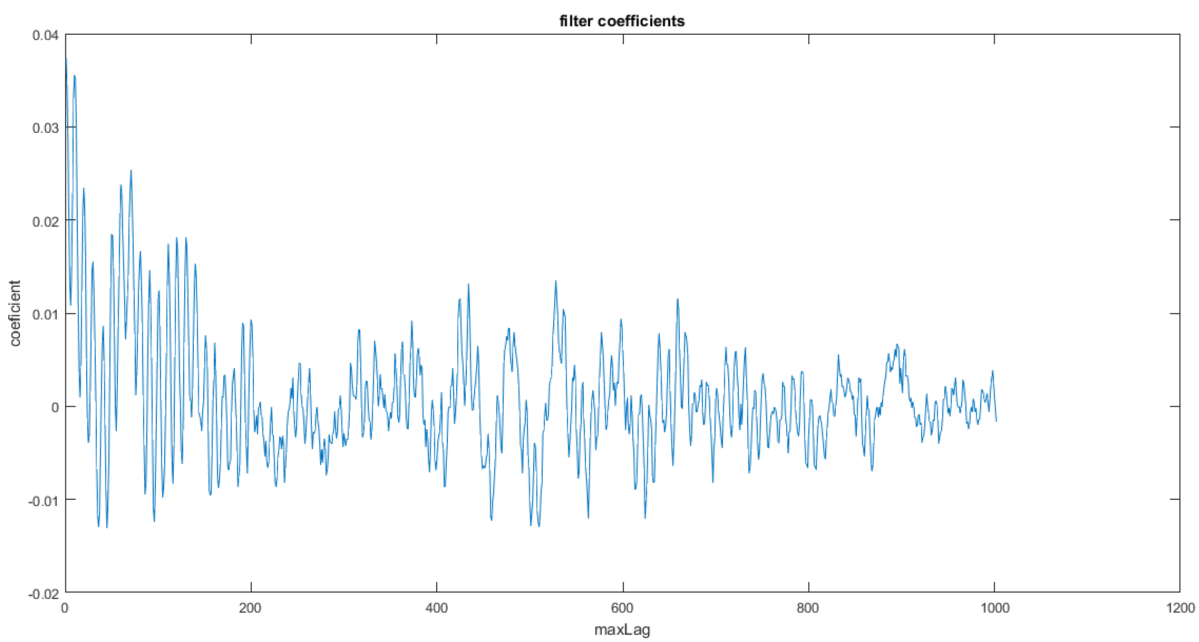

Fig 5: Filter Coefficients

As, we have an optimal adaptive filter, we can see that the filter coefficients varied a lot initially because it had to adapt the noisy signal to the original signal. But after few steps filter coefficients were adapted to reconstruct the original signal and hence, there is less transition in the coefficient values as compared to initial transition. It was expected from this filter.

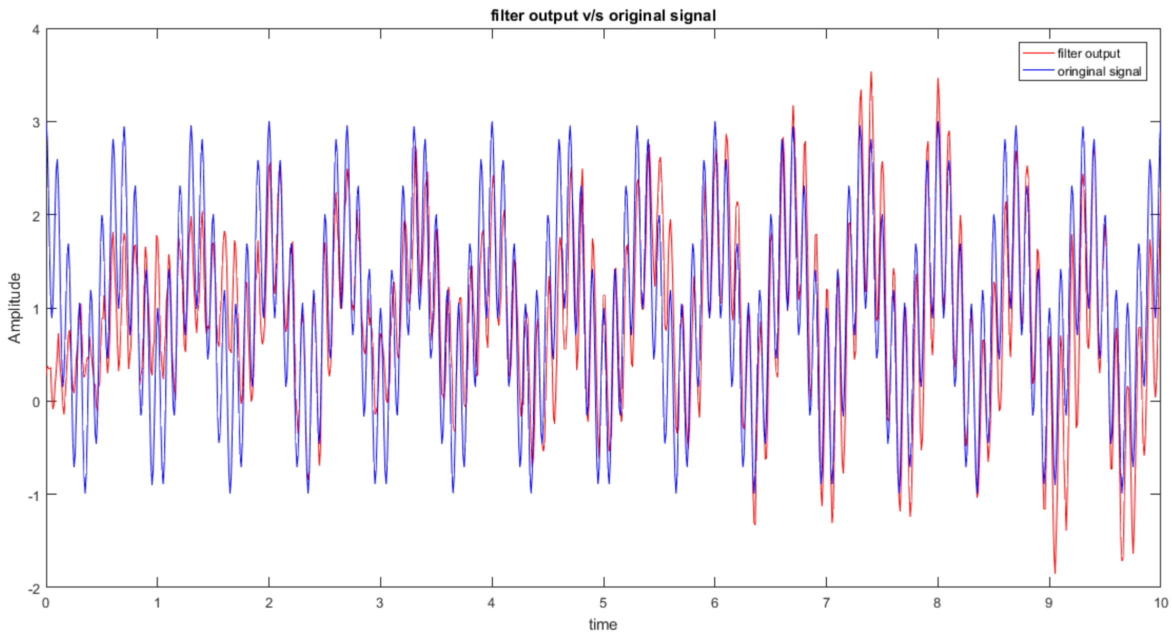

Fig 6: filter output v/s original signal

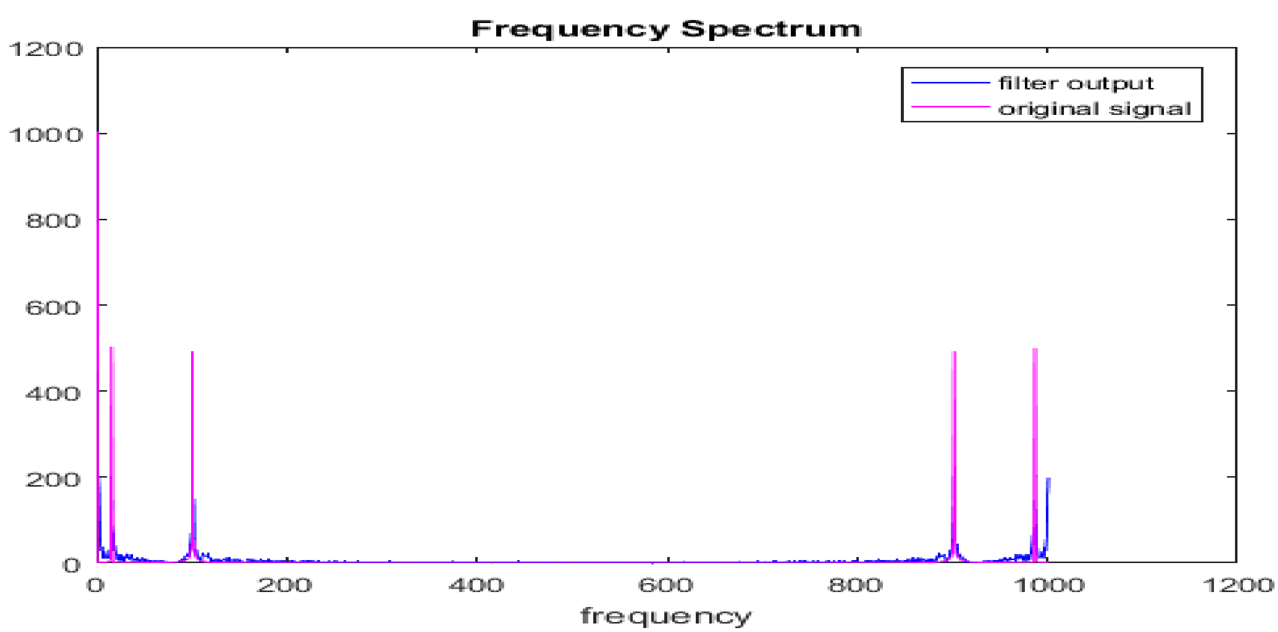

Fig 7: Frequency response

Initially, we could see the filter had problems adapting to the original signal. It was obvious as it needed data to adjust filter coefficients to get the noisy signal filtered close to the original signal. As soon as the filter was adapted, we can see that reconstructed output is approximately same as the original signal. Thus, we have achieved proper construction of optimal filter using Weiner-Hopf equations. In fig 7, we can see that the frequency response of the filtered output remains intact except that the fluctuations are not present in the response.