EE434 HOMEWORK REPORT

HW1

Name : Harun Durmuş **Date:** 11.11.2023

Student Name : 270206025

Questions & Answers

Q1. Analysis, Magnitude and Phase Spectrums of the given ecg signals (ecg_hfn, ecg_lfn, ecg_noisy)

Number of samples for 1 second for the ECG data is equal to Fs which is given 1000 Hz at the beginning. Total recording times in seconds for each ECG data is calculated below:

```
Fs = 1000;
Ts = 1/Fs;
Td_hfn = length(ecg_hfn)/Fs;
Td_lfn = length(ecg_lfn)/Fs;
Td_noisy = length(ecg_noisy)/Fs;
```

which are equal to 8.568 sn for ecg_hfn, 23.484 sn for ecg_lfn, 10.696 sn for ecg_noisy. From the beginning of the 2nd second to end of the 4th second has 3 seconds duration. Number of sample for the 3 second duration is equal to three times sampling frequency which is 3000. The length of the matrices are 1x3000.

```
start_time = 1;  % seconds
end_time = 4;    % seconds
indices_range = (start_time * Fs)  : (end_time * Fs) - 1;
new_hfn1 = ecg_hfn(indices_range);
new_lfn1 = ecg_lfn(indices_range);
new_noisy1 = ecg_noisy(indices_range);
time1 = indices_range/Fs;
```

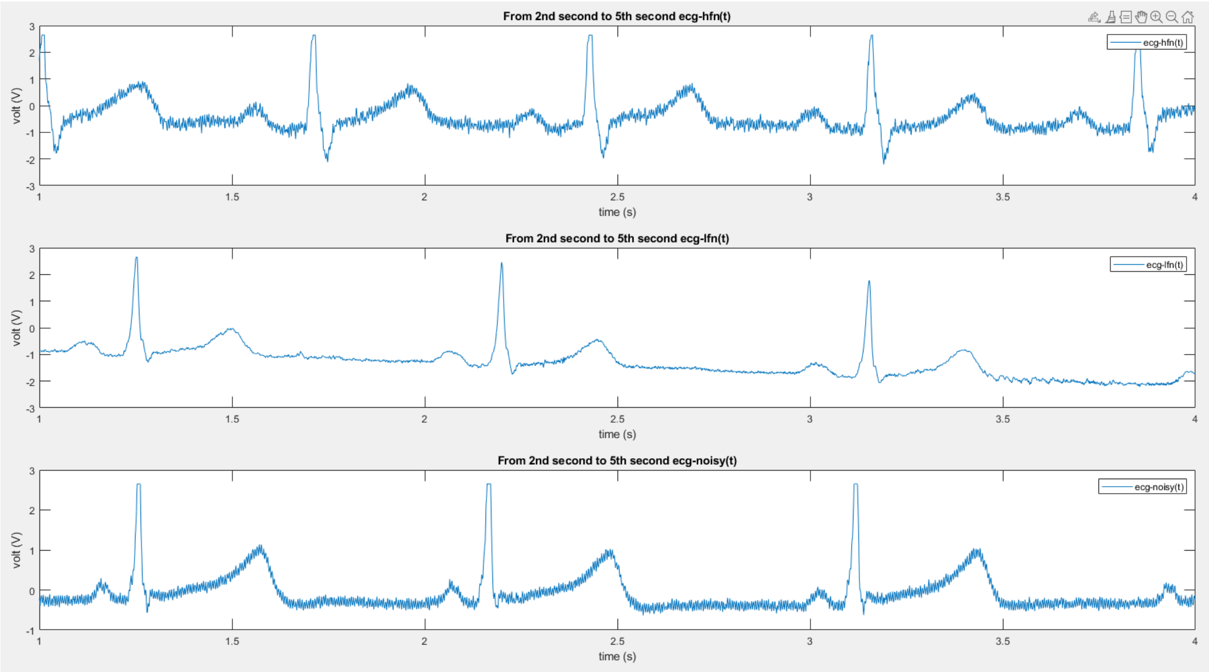

Figure 1: ecg_hfn, ecg_lfn, ecg_noisy (3 seconds)

The typical frequency band for an Electrocardiogram (ECG) signal is 0.05 to 100 Hz. This range captures the essential components of the ECG signal, including baseline wander (0.05-0.5 Hz), normal ECG frequencies (0.5-50 Hz) representing atrial and ventricular activity, and potential powerline interference (50 or 60 Hz). Understanding these frequency bands is crucial for signal processing and analysis, involving techniques such as filtering to enhance diagnostic capabilities by focusing on specific components of the signal. The ability to accurately identify and analyze these frequency components is essential for diagnosing various cardiac conditions.

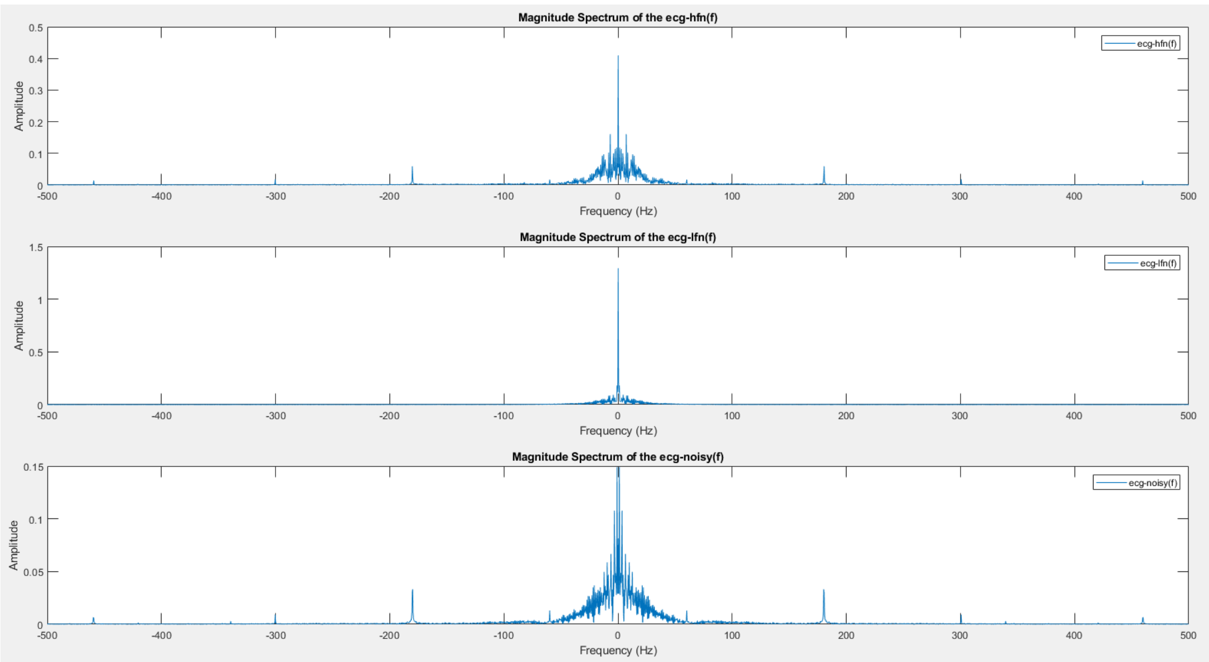

Figure 2: Magnitude spectrum of the ecg signals

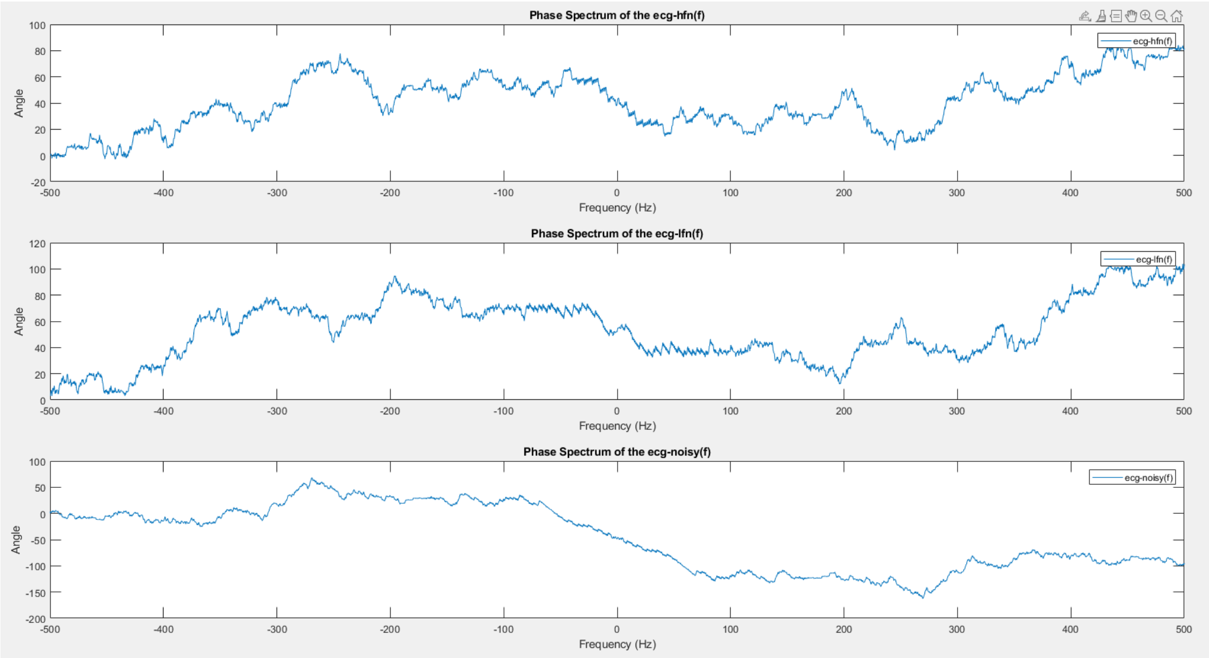

Figure 3: Phase Spectrum of the ecg signals

i. The first subfigure represents the high frequency noise. It can be observed from the figure 2 that frequency components are located between 0 to 100 Hz mostly. Also second subfigure is low frequency noise. The frequency components are located near zero (0 to 20 Hz). Last subfigure is band-limited noise.
ii. It can be observed that from the thirs subfigure in Figure 3 has linear phase response while others are non-linear.

```
start_time = 4;  % seconds
end_time = 7;    % seconds
indices_range2 = (start_time * Fs)  : (end_time * Fs) - 1;
new_hfn2 = ecg_hfn(indices_range2);
new_lfn2 = ecg_lfn(indices_range2);
new_noisy2 = ecg_noisy(indices_range2);
time2 = indices_range2/Fs;
N_hfn2 = length(new_hfn2);
N_lfn2 = length(new_lfn2);
N_noisy2 = length(new_noisy2);
fvec_hfn2 = linspace(-Fs/2, Fs/2, N_hfn2);
fvec_lfn2 = linspace(-Fs/2, Fs/2, N_lfn2);
fvec_noisy2 = linspace(-Fs/2, Fs/2, N_noisy2);
hfn_f2 = abs(fftshift(fft(new_hfn2,N_hfn2)))/N_hfn2;
lfn_f2 = abs(fftshift(fft(new_lfn2,N_lfn2)))/N_lfn2;
noisy_f2 = abs(fftshift(fft(new_noisy2,N_noisy2)))/N_noisy2;
phase_hfn2 = unwrap(angle(fftshift(fft(new_hfn2,N_hfn2))));
phase_lfn2 = unwrap(angle(fftshift(fft(new_lfn2,N_lfn2))));
phase_noisy2 = unwrap(angle(fftshift(fft(new_noisy2,N_noisy2))));
```

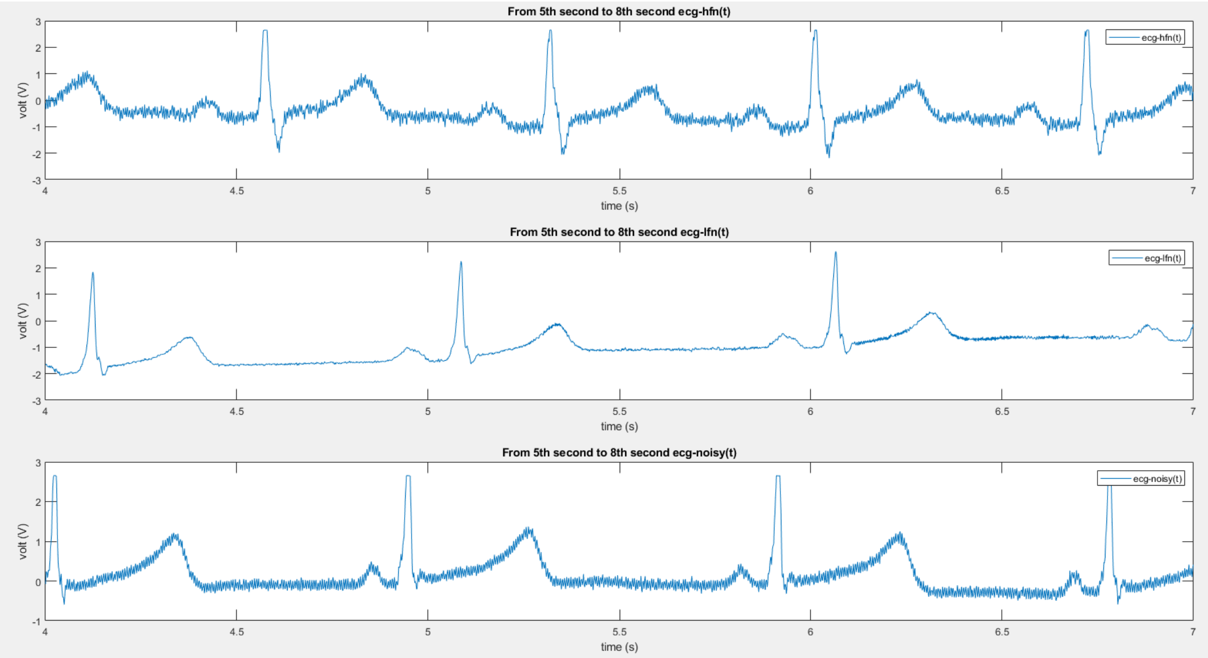

Figure 4: ecg_hfn, ecg_lfn, ecg_noisy (from 5th second to 8th second)

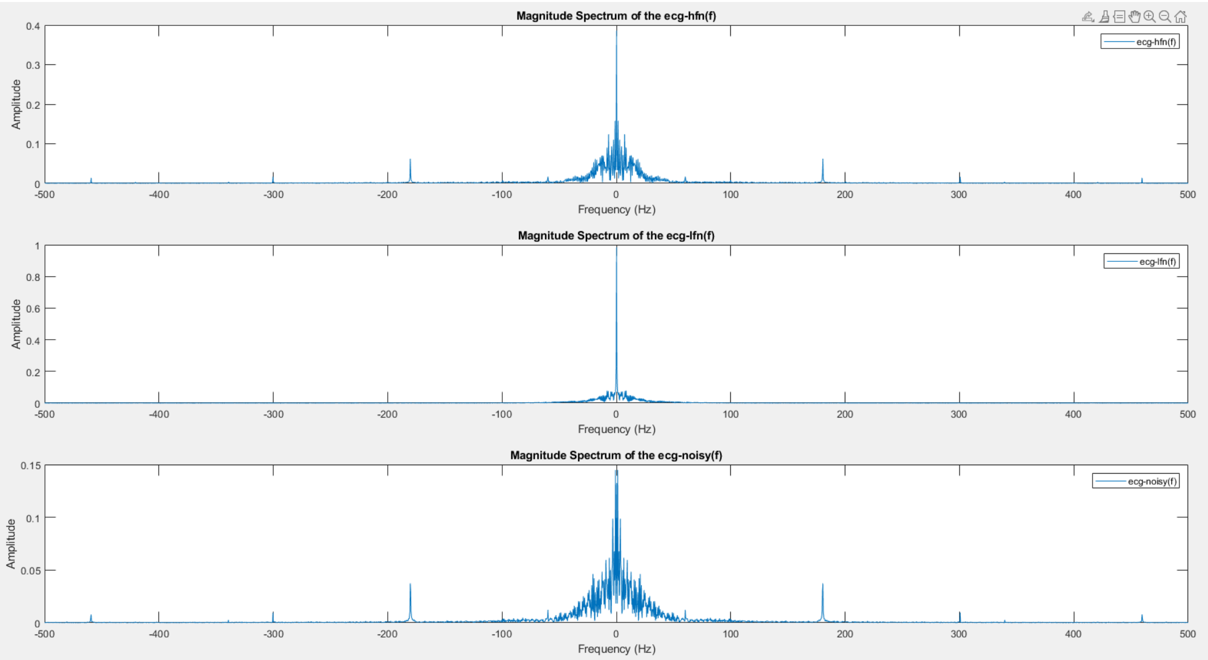

Figure 5: Magnitude spectrum of the ecg signals

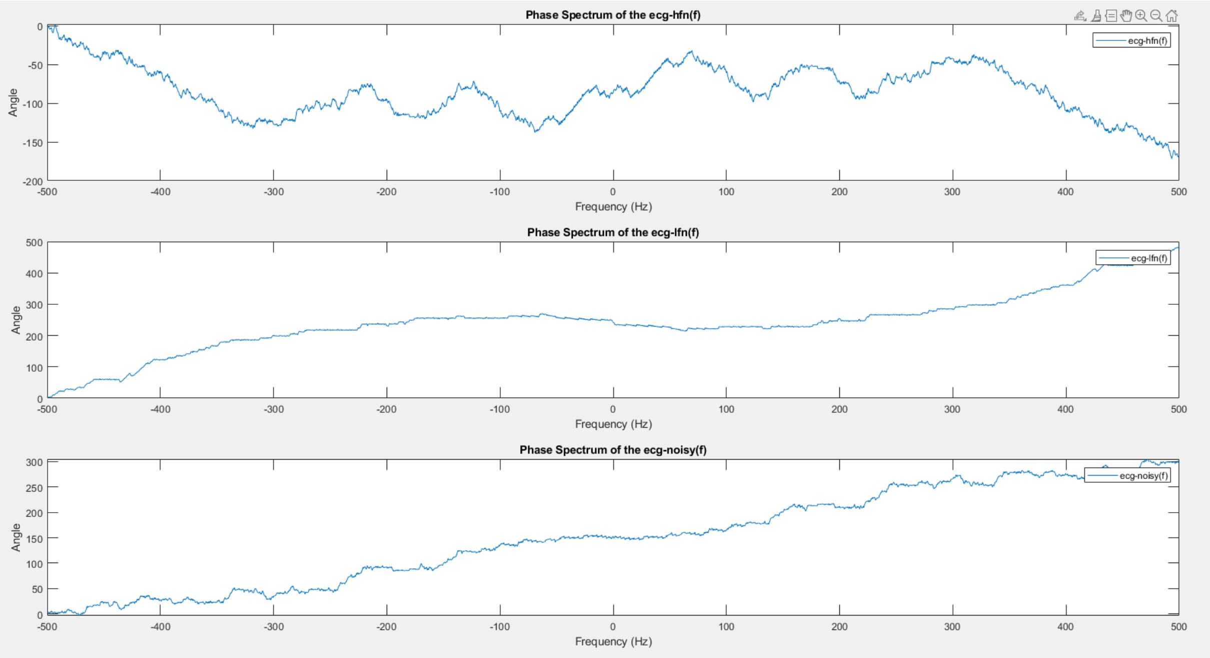

Figure 6: Phase Spectrum of the ecg signals

The difference between the two time sequence results can be observed from the figure 6. Band-limited noise which is in 3rd subfigure has linear phase response. The reason of this difference might be any diagnosis in the cardiovascular system which causes non-periodic impulses between the P-Q-R-S-T intervals.

Q2. Filtering

It is observed that both filtering operations are powerful for denoising.

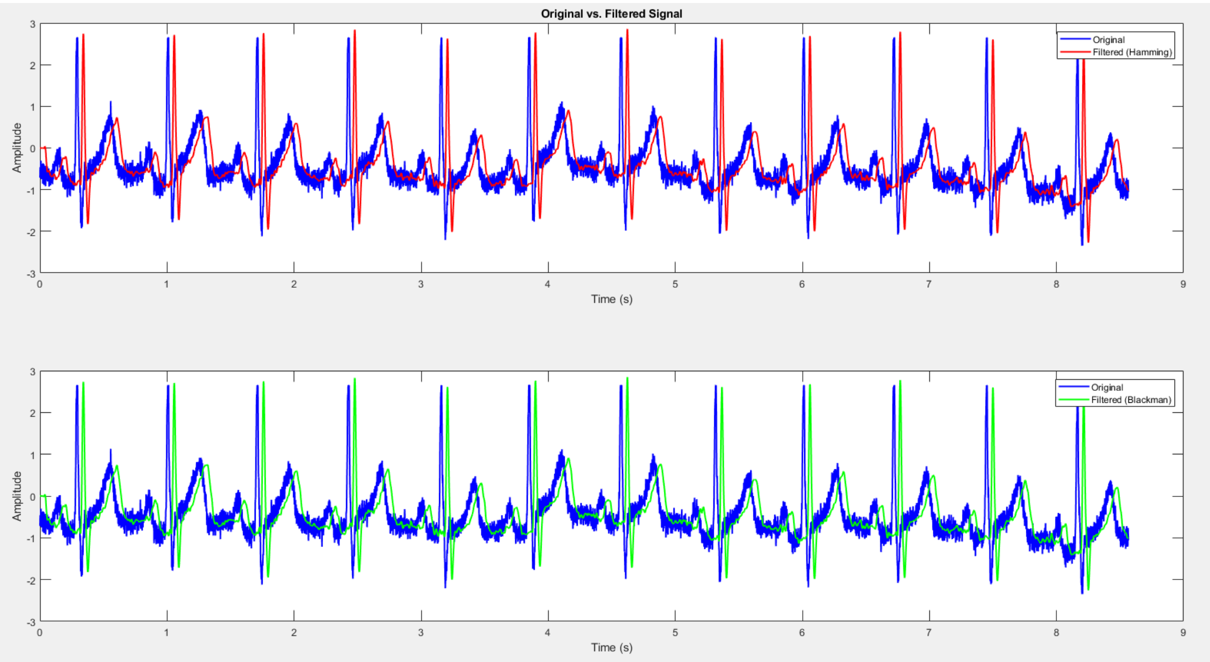

Figure 7: Original vs. Filtered Signals

```
Fs = 1000;
Ts = 1/Fs;
```

```
cutoff_freq = 50; % Adjust as needed
filter_order = 100; % Adjust as needed
hamming_window = hamming(filter_order + 1);
blackman_window = blackman(filter_order + 1);
fir_filter_hamming = fir1(filter_order, cutoff_freq/(Fs/2), 'low',
hamming_window);
fir_filter_blackman = fir1(filter_order, cutoff_freq/(Fs/2), 'low',
blackman_window);
filtered_signal_hamming = filter(fir_filter_hamming, 1, ecg_hfn);
filtered_signal_blackman = filter(fir_filter_blackman, 1, ecg_hfn);
```

Cut-off frequency and filter order can be adjusted as needed. In this configuration, the parameters above are optimum.

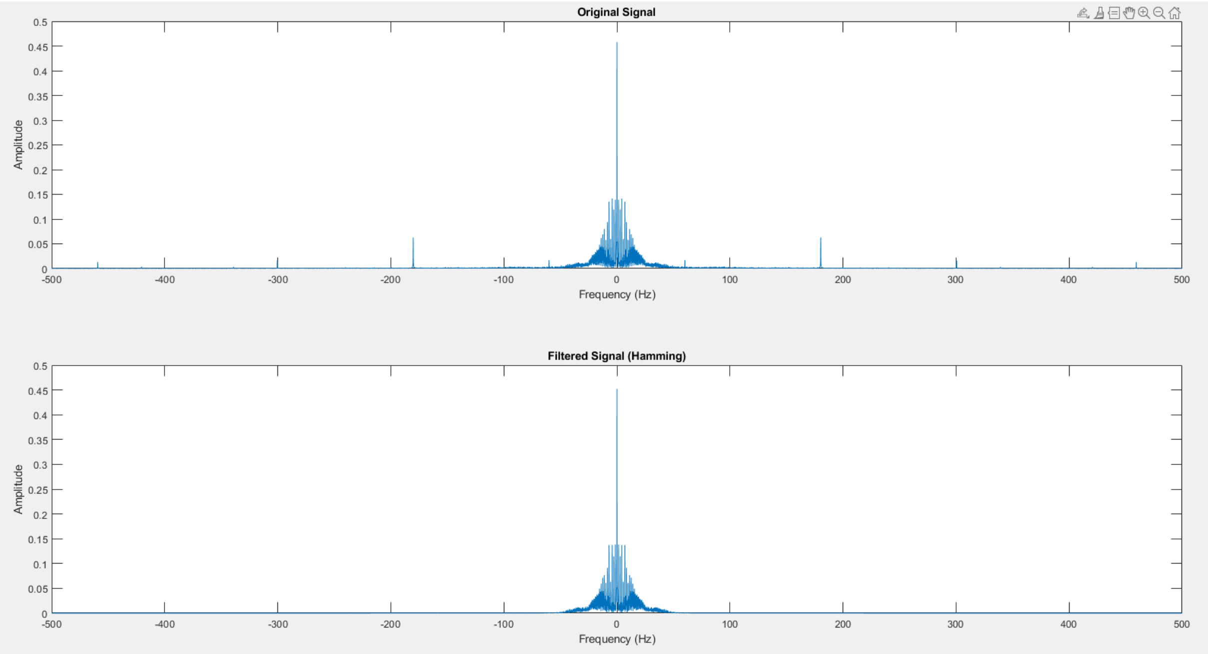

Figure 8: Frequency Response of Filtered Signals

The original signal and filtered signal has nearly the same frequency response which tells us the filtering process is successfull.