1 Preliminaries

In this week, we review the "filtering" subject which was previously covered in Signals & Systems lectures. In communication systems, filters are widely used to demodulate the received signals in the receivers. Filters can be examined in four categories which are low pass, high pass, band pass and band stop filters. These filters pass or reject the signals according to the cut-off frequencies in frequency domain. An ideal filter has a sharp frequency response which does not pass the frequency components of the signals beyond the desired cut-off frequency. For example, ideal low pass filters only pass the frequency components between 0 Hz and the determined cut-off frequency or ideal band pass filters only pass the signals between the desired two frequencies. Nonideal filters do not have a sharp frequency response and have a transition band around the cut-off frequency. This transition band can cause to have undesired frequency components. The filtering operation can be accomplished by multiplication in frequency domain.

For this week's experiment, it is useful to remember the functions that are employed in Week-1's experiment. Furthermore, it is also useful to learn about the Matlab functions *find(.)*, *butter(.)*, *freqz(.)* and *filter(.)* by using **Matlab Help** before doing the labwork given below.

In your reports, the details of the plots should be visible. Do not take screenshots to copy the figures plotted in Matlab. Instead, after plotting a Figure in Matlab, apply the following steps to copy the figure: Figure Window $-->$ Edit $-->$ Copy Figure.

2 Labwork

Read the preliminaries given above carefully before doing the experiment given below. **You must show the negative part of the frequency spectrum** in your figures.

2.1 Construction of the Signals

a. Construct $x_2(t) = \cos(120\pi t)+\cos(500\pi t)$ where the sampling frequency $f_s = 1000$ Hz and its duration is 2 s. Obtain the Fourier transform of $x_2(t)$ where the number of DFT points (N) is the length of the signal.

b. The magnitude of the frequency spectrum of $x(t)$, i.e., $|X(f)|$, is given in Fig. 1. Construct $|X(f)|$ which is a triangular signal between -50 Hz and 50 Hz. *Hint: You can use find(.) function in Matlab to find and change the nonzero components of the signal.*

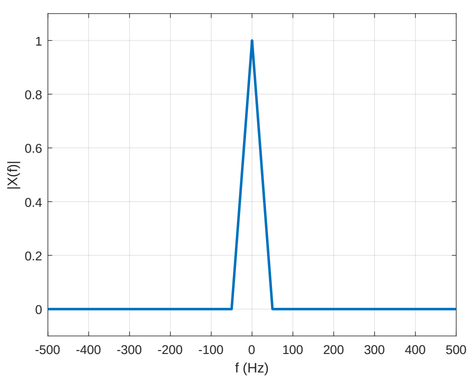

Figure 1: The plot of $|X(f)|$.

c. Generate the signal $|Y_1(f)|$ by using the relation $|Y_1(f)| = |X(f)| + |X_2(f)|$.

d. Plot $|X(f)|$, $|X_2(f)|$ and $|Y_1(f)|$ in the same figure (by using *subplot(3,1,.)* command) where x-axis shows the frequency in Hz.

2.2 Filtering

a. As shown in Fig. 2, filter $|Y_1(f)|$ with an ideal low pass filter, which has the frequency response $H_1(f)$, to obtain the nonzero frequency components of $|X(f)|$.

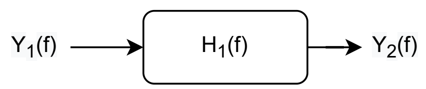

Figure 2: Block diagram of the filtering operation for $H_1(f)$.

b. Plot $|H_1(f)|$ and the filtered signal $|Y_2(f)|$ in the same figure (by using *subplot(2,1,.)* command) where x-axis shows the frequency in Hz.

c. As shown in Fig. 3, filter $|Y_1(f)|$ with an ideal band pass filter, which has the frequency response $H_2(f)$, to obtain the frequency components of $|X_2(f)|$ stemming from $\cos(500\pi t)$. *Hint: Do not forget to filter the negative frequency components!*

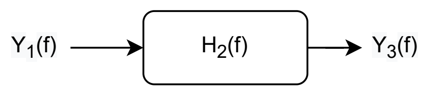

Figure 3: Block diagram of the filtering operation for $H_2(f)$.

d. Plot $|H_2(f)|$ and the filtered signal $|Y_3(f)|$ in the same figure (by using *subplot(2,1,.)* command) where x-axis shows the frequency in Hz.

e. Using *butter(.)* function, design a nonideal band pass filter, which has the frequency response $H_{bpf}(f)$ to obtain the frequency components of $|X_2(f)|$ stemming from $\cos(500\pi t)$. Filter $x_2(t)$ with $H_{bpf}(f)$ as shown in Fig. 4.

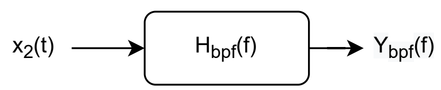

Figure 4: Block diagram of the filtering operation for $H_{bpf}(f)$.

f. Plot $|H_{bpf}(f)|$ and the filtered signal $|Y_{bpf}(f)|$ in the same figure (by using *subplot(2,1,.)* command) where x-axis shows the frequency in Hz. You can use *freqz(.)* function which does not show the negative part of the frequency spectrum to plot only the filter response.