Preliminaries

In this week, we review **'Filtering'** subject which was previously covered in Signals and Systems lectures. In communication systems, filters are widely employed in the receivers to demodulate and post process the received signals.

Mainly, there are four types of filters as low pass, high pass, band pass and band stop filters. Ideal low pass filters only pass the frequency components between 0 and determined cut off frequency or ideal band pass filters only pass the signals between the desired two frequencies. An ideal filter has a sharp frequency response which does not pass the frequency components of the signals beyond the desired cut off frequency. Non ideal filters 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 convolution in time domain and multiplication in frequency domain.

For this homework, you should learn about the functions **butter(.)**, **freqz(.)** and **filter(.)** by using MATLAB help. In your reports, the details of the plots should be visible.

1 Homework 2

Read the preliminaries given above carefully before doing the homework given below.

1.1 Input Signal

a. Construct the signal $x(t)$ which is defined in Eq. (1) where $f_1 = 20$ Hz, $f_2 = 50$ Hz, $f_3 = 1k$ Hz and $f_4 = 5k$ Hz. The duration of the signal is $0.5s$ and sampling frequency is equal to $F_s = 20k$ Hz.

$$x\left(t\right) = 5sin\left(2\pi f_1 t\right) + cos\left(2\pi f_2 t\right) + 15cos\left(2\pi f_3 t\right) + 10cos\left(2\pi f_4 t\right) \tag{1}$$

b. Use **subplot(2xx)** function to plot the following:

Plot $x(t)$ in time domain where x-axis shows the time in seconds.

Plot the frequency response of $x(t)$. **Choose the best fft length and explain it in the report.**

c. **Make sure to put title, label and legends to your figures to get full points!**

1.2 Filter Design

a. Create a low-pass filter (LPF) to obtain the frequency component of $x(t)$ where $f_1 = 20$ Hz.
Hint: Choose the appropriate filter order and cut-off frequency. Explain your choosing in the report!

Plot the magnitude response of the designed LPF.

b. Create a high-pass filter (HPF) to obtain the frequency component of $x(t)$ where $f_4 = 5k$ Hz.
Hint: Choose the appropriate filter order and cut-off frequency. Explain your choosing in the report!

Plot the magnitude response of the designed HPF.

c. Create a band-pass filter (BPF) to obtain the frequency component of $x(t)$ where $f_3 = 1k$ Hz.
Hint: Choose the appropriate filter order and cut-off frequency. Explain your choosing in the report!

Plot the magnitude response of the designed BPF.

d. **Make sure to put title, label and legends to your figures to get full points!**

1.3 Filtering

a. Filter $x(t)$ with the above designed filters.

b. Plot each of the signals' frequency responses using subplot(22x) where subplot(2,2,1) is the original signal $x(t)$.

c. **Make sure to put title, label and legends to your figures to get full points!**