Design of Filters

Problem : Design LPF, HPF, BPF and Moving Average filter with specifications as given below.

Steps :
For LPF, HPF and BPF
1. Generate the sinc pulse in time domain for the filter which you want to design
2. After generating the sinc pulse pass it through window functions
   a. Rectangular a window
   b. Hamming window

Technical Details :
Generate N samples of sinc pulse. You have to consider both positive and negative samples.

1. LPF
inputs : fc=300Hz, fs= 1200Hz, N=39

$$hd[n]=\frac{\sin(w_c*n)}{\pi*n} \quad \text{where} \quad -(N-1)/2 \leqslant n \leqslant (N-1)/2$$

for n=0, $hd[n]=\frac{w_c}{\pi}$

N= number of taps(number of samples) of sinc pulse.
$w_c=2*\pi*fc/fs$ fs= sampling frequency.

<u>Note:</u> You can choose any fc and fs as per your requirement of LPF and also as per Nyquist rate. But to design a Half band Filter fc=fs/4. Here consider the given parameters above.

After this you have to pass this sinc pulse through a window function W[n] defined as below.

a. Rectangular window $W_{rect}[n]=\begin{Bmatrix} 1, & if \quad 0 \leqslant n \leqslant N-1 \\ 0, & othrewise \end{Bmatrix}$

b. Hamming window $W_H[n]=\begin{Bmatrix} 0.54-0.46\cos(2*\pi*n/(N-1)), & if \quad 0 \leqslant n \leqslant N-1 \\ 0, & othrewise \end{Bmatrix}$

The final impulse reponse should be
a. $h[n]=hd[n]\times W_{rect}[n]$
b. $h[n]=hd[n]\times W_H[n]$

2. HPF

inputs : fc=1200Hz, fs= 4800Hz, N=39

$$hd[n]=\frac{\sin(\pi*n)-\sin(w_c*n)}{\pi*n} \quad \text{where} \quad -(N-1)/2 \leqslant n \leqslant (N-1)/2$$

for n=0, $hd[n]=1-\frac{w_c}{\pi}$ and $w_c=2*\pi*fc/fs$

After this follow the same windowing method as given above to generate h[n].

3. BPF

inputs : fc1=500 Hz, fc2=1200 Hz, fs= 6000Hz, N=39

$w_{c1}=2*\pi*fc1/fs$, $w_{c2}=2*\pi*fc2/fs$

$$hd[n]=\frac{\sin(w_{c2}*n)-\sin(w_{c1}*n)}{\pi*n} \quad \text{where} \quad -(N-1)/2 \leqslant n \leqslant (N-1)/2$$

for n=0, $hd[n]=\frac{w_{c2}-w_{c1}}{\pi}$

After this follow the same windowing method as given above to generate h[n].

Moving Average Filter :

input : x[n]= [-0.7145 1.3514 -0.2248 -0.5890 -0.2938 -0.8479 -1.1201 2.5260 1.6555 0.3075 -1.2571 -0.8655 -0.1765 0.7914 -1.3320 -2.3299 -1.4491 0.3335 0.3914 0.4517 -0.1303 0.1837 -0.4762 0.8620 -1.3617 0.4550 -0.8487 -0.3349 0.5528 1.0391]

find output $y[n]=\frac{1}{L}\sum_{k=0}^{L-1} x[n-k]$

For your simulation take L=5.

Submission Details :

Write functions in C for LPF, HPF, BPF and Moving Average Filter.

Inputs to your function is as given above for each case and output is h[n] for LPF, HPF, BPF. Output for Moving Average Filter is y[n].

Take the h[n](only Hamming window results) generated in C to matlab to plot your filter magnitude response as given below.

Step1: Replace existing coefficients with your h[n] coefficients in filter_coefficients.txt
Step2. Run Matlab file filter_visualization.m

Note : please keep filter_coefficients.txt and filter_visualization.m files in same folder/path