# EE5301: DSP Lab/EE5801: CSP Lab

# Assignment 4

## Problem:

Design of digital filters such as LPF,HPF,BPF.

## Technical details:

1. **LPF or Half band filter** with $f_c = 400\ Hz$, $\omega_c = \pi/2$, $N = 39$

$$h_d[n] = \begin{cases} \dfrac{Sin(\omega_c\, n)}{\pi\, n}, & -(N-1)/2 \le n \le (N-1)/2 \\ \dfrac{\omega_c}{\pi}, & n = 0 \end{cases}$$

2. **LPF** with $f_c = 400\ Hz$, $\omega_c = \pi/4$, $N = 39$, $h_d[n]$ is same as above.
3. **HPF** with $f_c = 1200\ Hz$, $f_s = 4800\ Hz$, $N = 39$

$$h_d[n] = \begin{cases} \dfrac{Sin(\pi n)}{\pi\, n} - \dfrac{Sin(\omega_c\, n)}{\pi\, n}, & -(N-1)/2 \le n \le (N-1)/2 \\ 1 - \dfrac{\omega_c}{\pi}, & n = 0 \end{cases}$$

4. **BPF** with $f_{c1} = 500\ Hz$, $f_{c2} = 1200\ Hz$, $f_s = 6000\ Hz$, $N = 39$

$$h_d[n] = \begin{cases} \dfrac{Sin(\omega_{c2} n)}{\pi\, n} - \dfrac{Sin(\omega_{c1}\, n)}{\pi\, n}, & -(N-1)/2 \le n \le (N-1)/2 \\ \dfrac{\omega_{c2} - \omega_{c1}}{\pi}, & n = 0 \end{cases}$$

### Window functions

- Hamming window

$$W_H[n] = \begin{cases} 0.54 - 0.46\cos\left(\frac{2\pi n}{N-1}\right), & if\ 0 \le n \le N-1 \\ 0, & otherwise \end{cases}$$

## Instructions:

- In case of 1 and 2 please decide the sampling frequency $f_s$ as discussed in lecture.

- Generate the $N$ samples of $h_d[n]$ in time domain for the filter you want to design.
- Multiply the window function $W_H[n]$ with $h_d[n]$ to get practical impulse response $h[n]$.

## **Submission Details:**

- Write C code to implement above system.
- Write main.c and two separate files named common_functions.c which contains 3 separate functions corresponding to LPF and HPF and BPF and header file named common_functions.h which contains function declarations. For both LPF 1 and LPF 2 you need to call same LPF function with appropriate parameter. Input to any filter functions are $f_c$, $f_s$ and $N$. Output of any filter function is $h[n]$.
- Upload main.c, common_functions.c, common_functions.h files and a text file containing your practical impulse response $h[n]$ for all four cases.
- Also write your understanding about above filters in your own words and upload a pdf file.
- Submit all files in a single zip file with your id, Example: EE20MTECH11010_**A1**.zip.