Assignment 1 — DSP Lab

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January 2022

1 Problem

Design of digital filters such as Low Pass Filter (LPF), Half Band Filter (HBF).

2 Filter Design Details

1. LPF (Half Band Filter) : F_c=400Hz, w_c=$\pi/2$, N=39
2. LPF : F_c=400Hz, w_c=$\pi/4$, N=39

3 Understanding & Outcomes

For any Digital Signal Processing block, designing a Low Pass Filter is key step to begin with. An LPF has sampling frequency(F_s), cutoff frequency(F_c) and Filter length(N). Sampling frequency for any LPF can be calculated by below formula:

$$F_s = \left\{ \frac{2.\pi.F_c}{w_c} \right. \tag{1}$$

where w_c stands for digital frequency.

In this work, we are designing Linear phase Finite Impulse Response (FIR) filter using windowing method. Time domain impulse response samples are generated and passed through a window called Hamming Window.

$$h_d[n] = \begin{cases} \frac{sin(w_c n)}{\pi.n} & \text{-(N-1)/2} \leq \text{n} \leq \text{(N-1)/2} \\ \frac{w_c}{\pi} & \text{n=0} \end{cases} \tag{2}$$

Due to consideration of finite length of filters, ripples are generated in both passband and stopband. Use of Hamming window reduces the magnitudes of the ripples in frequency response and hence give more accurate filter design.

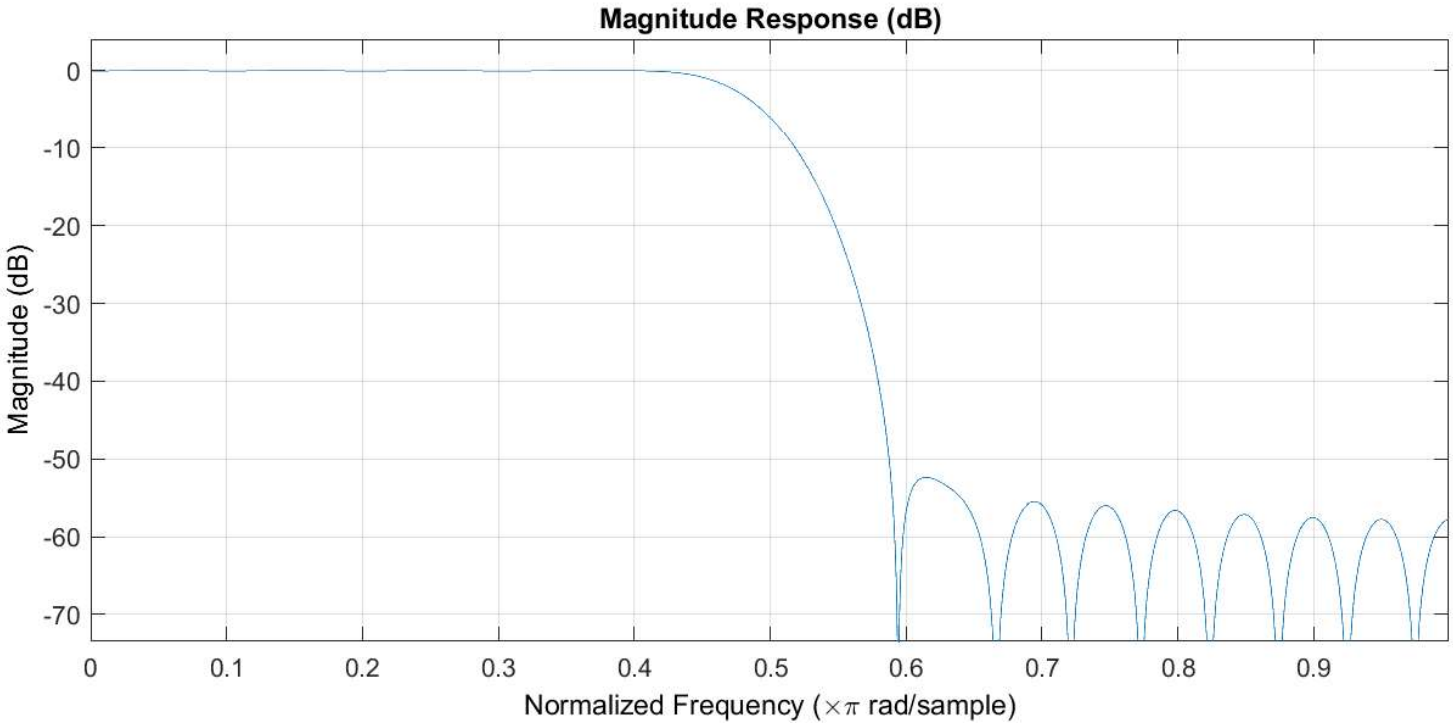
$$W_H[n] = \begin{cases} 0.54 - 0.46 * cos(\frac{2\pi.n}{N-1}) & 0 \leq \text{n} \leq \text{(N-1)} \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

Practical low pass filter impulse response : h[n] = $h_d[n]$ X w[n]

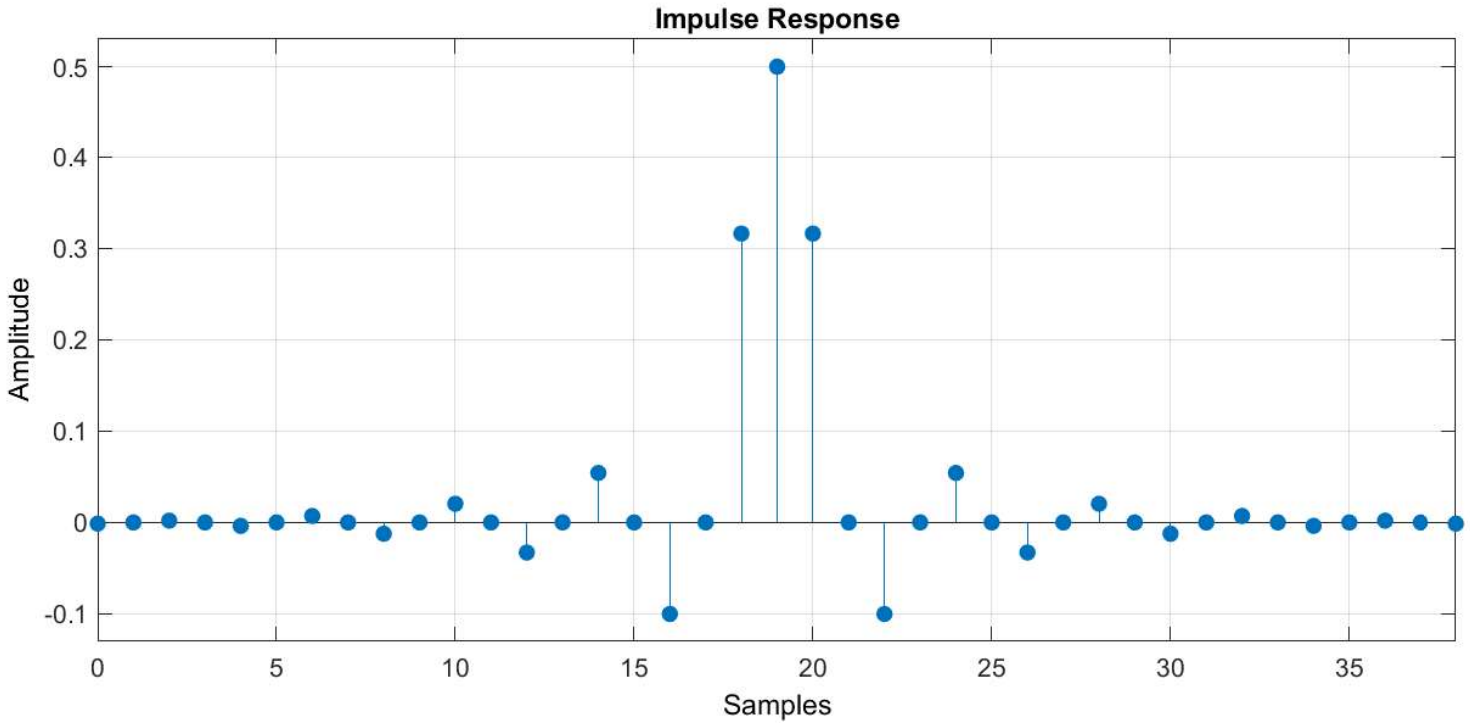
4 MATLAB Plots for Frequency Response

Frequency response for impulse responses of design LPF can be obtained by using "fvtool" function in Signal Processing Toolbox of MATLAB tool. Below are the plots obtained:

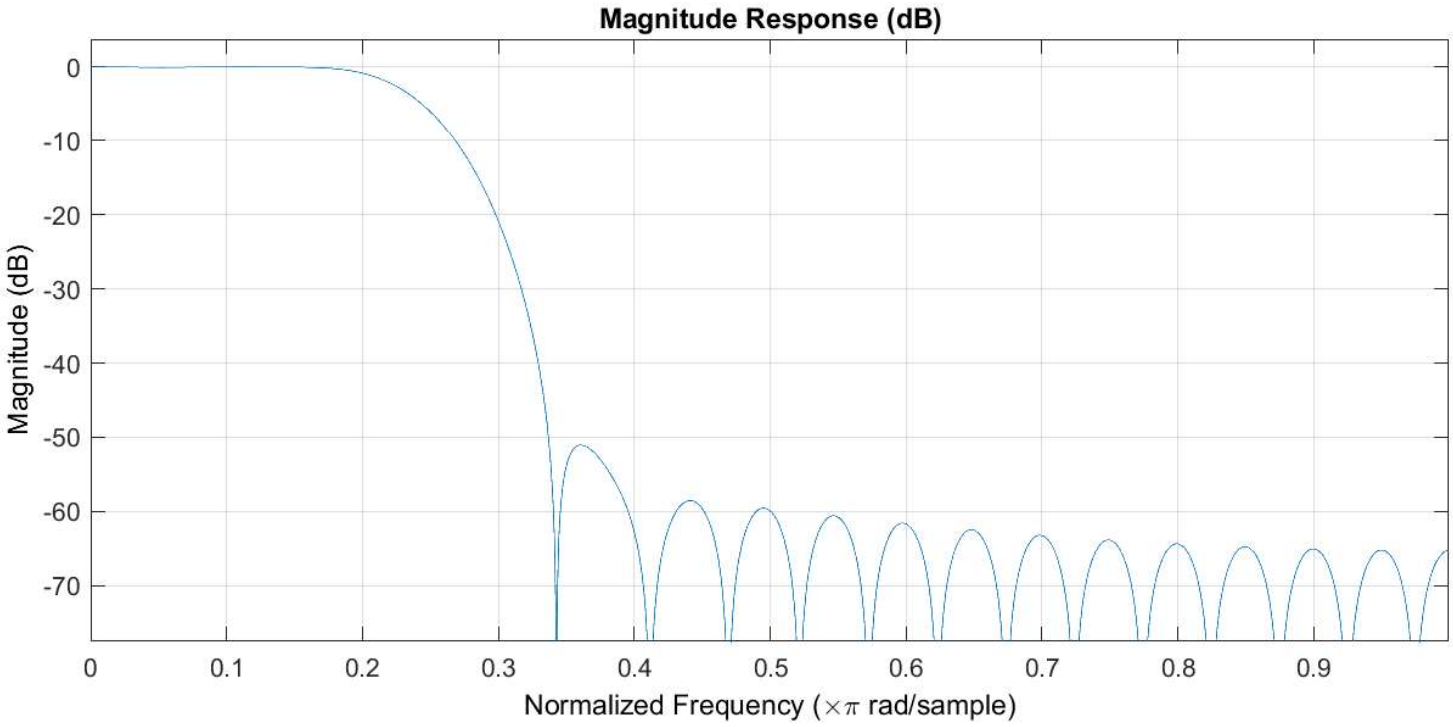
4.1 Half Band LPF Frequency Response



4.2 Half Band LPF Impulse Response



4.3 Half Band LPF Frequency Response



4.4 LPF Impulse Response