Lab Report-2
EE3701- Communication Systems Lab
Digital Filter Design

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EE20BTECH11012

1 Low Pass Filter

1.1 LPF-1

1.1.1 Given specifications

1. $\omega_c = \frac{\pi}{2}$
2. $f_c = 400Hz$
3. N=39

- Infinite Length Impulse Response function

$$h_d[n] = \begin{cases} \frac{sin(\omega_c.n)}{\pi.n} & for \quad -(N-1)/2 \leq n \leq (N-1)/2 \\ \frac{\omega_c}{\pi} & for \;\; n = 0 \end{cases}$$

- Window function

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

- Sampling frequency

$$\Rightarrow f_s = \frac{2\pi f_c}{w_c}$$

Finite length impulse response is obtained by

$$h[n] = h_d[n].W_H[n]$$

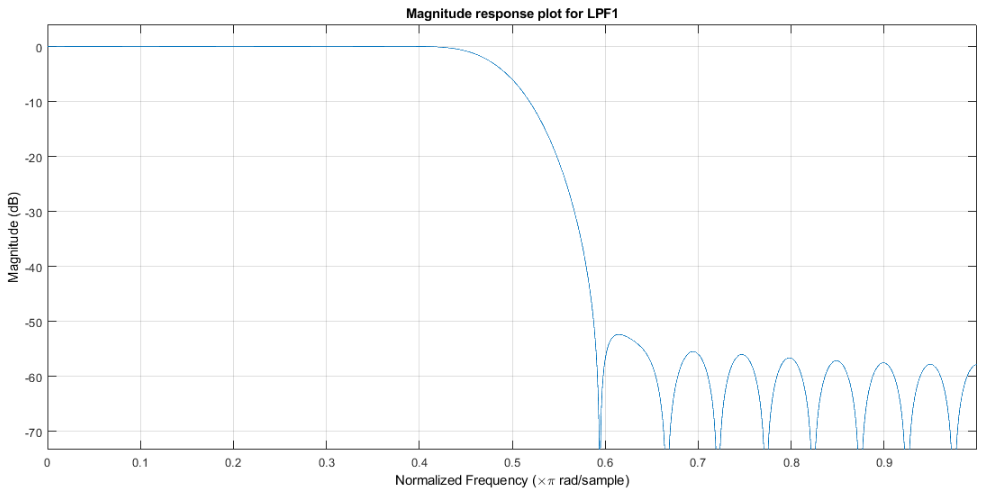

Figure 1: Magnitude Response of LPF with $\omega_c = \frac{\pi}{2}$

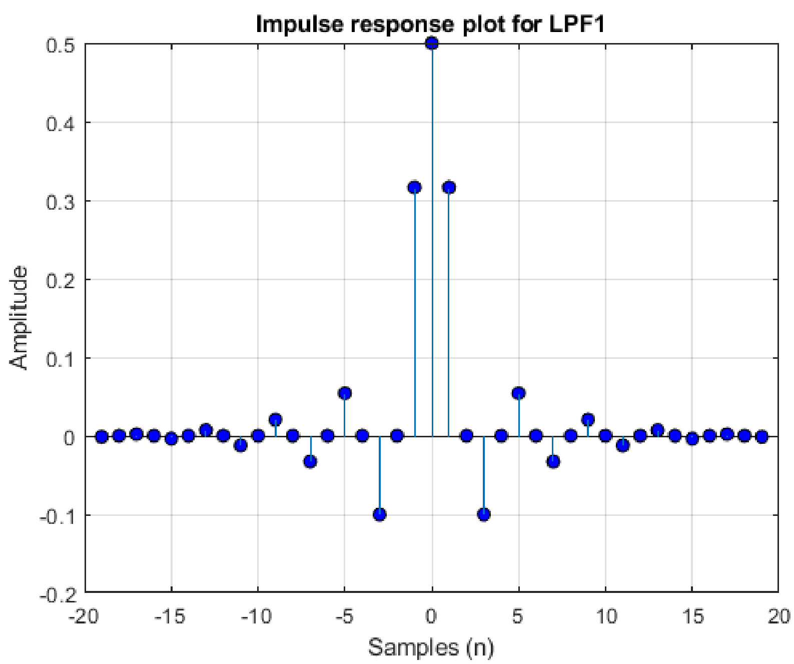

Figure 2: Impulse Response of LPF with $\omega_c = \frac{\pi}{2}$

1.1.2 Observations

From above Magnitude Response

- Passband Ripple ($\delta 1$)=0;
- Stopband Ripple ($\delta 2$) $\approx -52.7dB$
- Passband edge ripple $\omega_p = 0.4\pi \;\; rad/sample$
- Stopband edge ripple $\omega_s = 0.59\pi \;\; rad/sample$

$\Rightarrow$ ω_c is in between ω_p and ω_s.
$\Rightarrow$ Width of Passband > Width of Stopband.

In the Impulse response, we can observe that the wave is a sinc wave of finite length with higher amplitude 0.5.

1.2 LPF-2

1.2.1 Given specifications

1. $\omega_c = \frac{\pi}{4}$
2. $f_c = 400Hz$
3. N=39

As discussed above all equations remain same

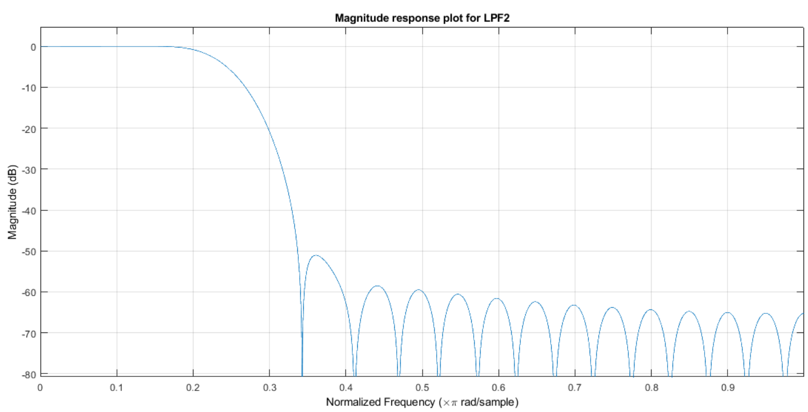

Figure 3: Magnitude Response of LPF with $\omega_c = \frac{\pi}{4}$

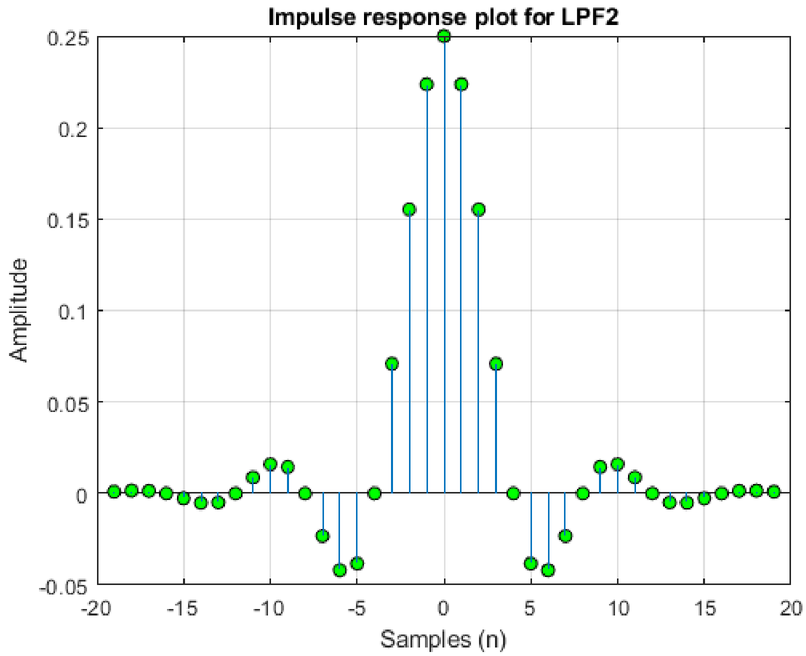

Figure 4: Impulse Response of LPF with $\omega_c = \frac{\pi}{4}$

1.2.2 Observations

From above Magnitude Response

- Passband Ripple ($\delta1$)=0;
- Stopband Ripple ($\delta2$) $\approx -53.5dB$
- Passband edge ripple $\omega_p = 0.17\pi \;\; rad/sample$
- Stopband edge ripple $\omega_s = 0.35\pi \;\; rad/sample$

$\Rightarrow$ ω_c is in between ω_p and ω_s.
$\Rightarrow$ Width of Passband < Width of Stopband.

In the Impulse response, we can observe that the wave is a sinc wave of finite length with higher amplitude 0.25.

1.3 Comparing LPF-1 and LPF-2

- LPF-1 has more Pass band width and less stopband width compared to LPF-2.

- Impulse response of LPF-1 has higher amplitude than LPF-2.
- Therefore LPF-1 is better filter compared to LPF-2.

2 Band Pass Filter

Infinite Length Impulse response

$$h_d[n] = \begin{cases} \frac{sin(\omega_{c2}.n)}{\pi.n} - \frac{sin(\omega_{c1}.n)}{\pi.n} & for \quad -(N-1)/2 \leq n \leq (N-1)/2 \\ \frac{\omega_{c2}-\omega_{c1}}{\pi} & for \;\; n = 0 \end{cases}$$

Window function

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

Finite length impulse response is obtained by

$$h[n] = h_d[n].W_H[n]$$

Given

$$f_{c1} = 500Hz, \;\; f_{c2} = 1200Hz, \;\; f_s = 6000Hz, \;\; N = 39$$

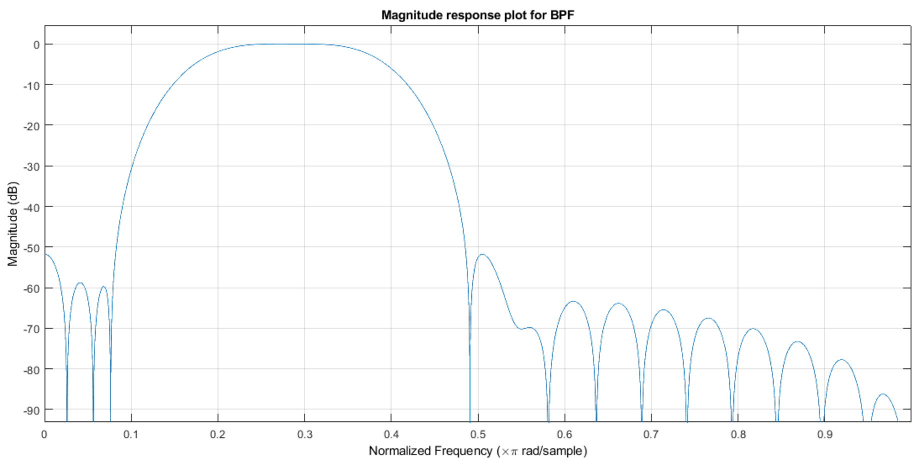

Figure 5: Magnitude Response of BPF with $f_{c1} = 500Hz, \;\; f_{c2} = 1200Hz, \;\; f_s = 6000Hz$

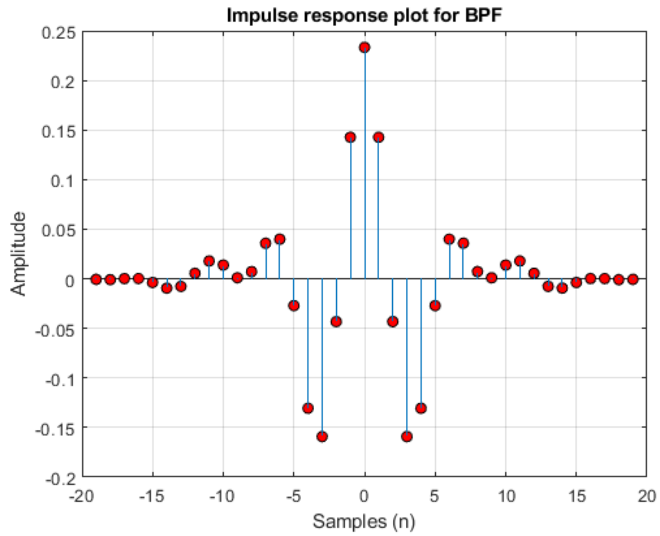

Figure 6: Impulse Response of BPF with $f_{c1} = 500Hz,\ f_{c2} = 1200Hz,\ f_s = 6000Hz$

2.1 Observations

- In Impulse response sinc wave amplitude is nearly 0.25.
- In the magnitude response the signals whose frequencies are between cut-off they are amplified and other are attenuated.
- Bandwidth = 700Hz = $0.233\pi rad/sample$
- Critical Frequency

$$f_o = \sqrt{f_{c1}.f_{c2}} = 774.596Hz$$

- Quality Factor

$$Q = \frac{f_o}{BW} = 1.106$$

As Q<10 the filter has wide flat response over the range of frequencies, So this is called **"Wide Band Pass Filter"**