Experiment No: 5

Experiment Name: Frequency Response Comparison of Different Filter Designs

Theory:

Filters are essential components in signal processing systems. They are used to allow or block certain frequency ranges in a signal. Filters can be categorized into four types based on their frequency response:

1. **Low-Pass Filters (LPF):** Allow frequencies below a cutoff frequency and attenuate higher frequencies.
2. **High-Pass Filters (HPF):** Allow frequencies above a cutoff frequency and attenuate lower frequencies.
3. **Band-Pass Filters (BPF):** Allow frequencies within a specific range and attenuate those outside this range.
4. **Band-Stop Filters (BSF):** Block frequencies within a certain range while passing others.

Popular designs of filters include:

- **Butterworth Filters:** Characterized by a flat response in the passband.
- **Chebyshev Filters:** Have steeper roll-offs but exhibit ripples in the passband (Type I) or stopband (Type II).
- **Elliptic Filters:** Provide the steepest roll-off but with ripples in both the passband and stopband.

Objective:

To analyze and compare the frequency response of different filter designs, including Butterworth, Chebyshev, and Elliptic filters, and evaluate their performance in terms of:

- Passband characteristics.
- Stopband attenuation.
- Roll-off steepness.

Output:

```
figure(1)
[h, w] = freqz([1], [1 -0.4], 1024); % Numerator [1], Denominator [1 -0.4]
phi = 180 * unwrap(angle(h)) / pi;   % Calculate phase response in degrees
subplot(2,1,1), plot(w, abs(h)), grid;
xlabel('Frequency (radians)'), ylabel('Magnitude');
title('Magnitude Response for Case a');
subplot(2,1,2), plot(w, phi), grid;
xlabel('Frequency (radians)'), ylabel('Phase (degrees)');
title('Phase Response for Case a');
```

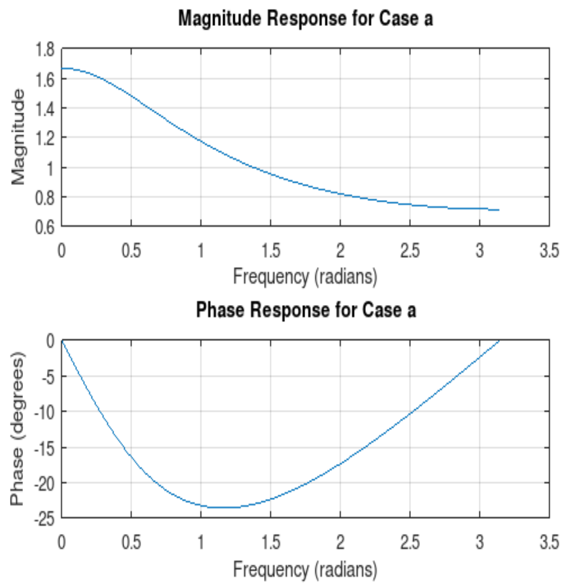

FIGURE 1: Case A

```
figure(2)

[h, w] = freqz([1 -0.4], [1], 1024); % Numerator [1 -0.4], Denominator [1]

phi = 180 * unwrap(angle(h)) / pi;   % Calculate phase response in degrees

subplot(2,1,1), plot(w, abs(h)), grid;

xlabel('Frequency (radians)'), ylabel('Magnitude');

title('Magnitude Response for Case b');

subplot(2,1,2), plot(w, phi), grid;

xlabel('Frequency (radians)'), ylabel('Phase (degrees)');

title('Phase Response for Case b');
```

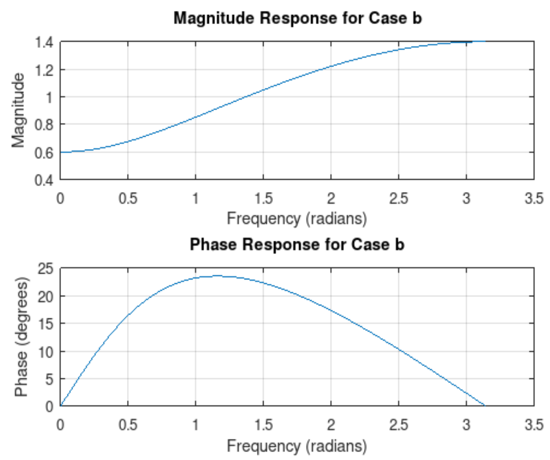

FIGURE 2: Case B

```
figure(3)

[h, w] = freqz([0.4 -0.3], [1 -0.5 0.2], 1024); % Numerator [0.4 -0.3], Denominator [1 -0.5 0.2]

phi = 180 * unwrap(angle(h)) / pi;           % Calculate phase response in degrees

subplot(2,1,1), plot(w, abs(h)), grid;

xlabel('Frequency (radians)'), ylabel('Magnitude');

title('Magnitude Response for Case c');

subplot(2,1,2), plot(w, phi), grid;

xlabel('Frequency (radians)'), ylabel('Phase (degrees)');

title('Phase Response for Case c');
```

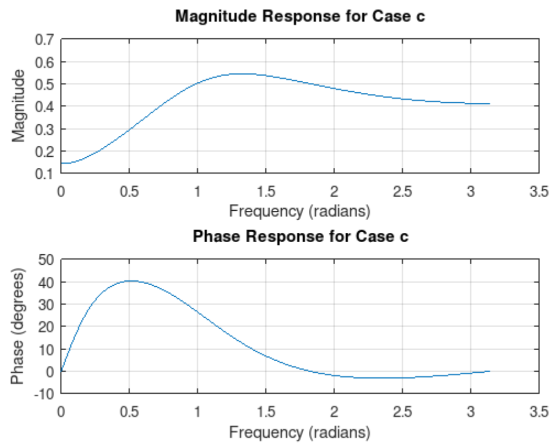

FIGURE 3: Case C

```
Figure(4)

[h, w] = freqz([1 -0.8 0.6], [1 -0.4 0.3], 1024);

phi = 180 * unwrap(angle(h)) / pi;

subplot(2,1,1), plot(w, abs(h)), grid;

xlabel('Frequency (radians)'), ylabel('Magnitude');

title('Magnitude Response for Case d');

subplot(2,1,2), plot(w, phi), grid;

xlabel('Frequency (radians)'), ylabel('Phase (degrees)');

title('Phase Response for Case d');
```

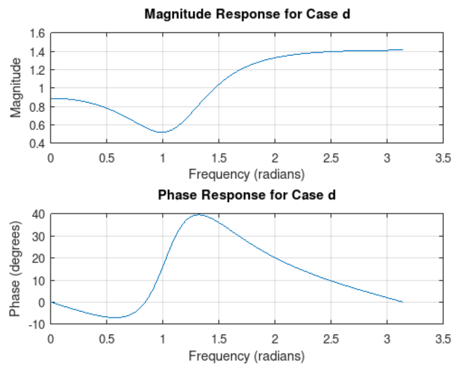

FIGURE 4: Case D

Discussion: In this lab, we analyzed the frequency response of different digital filters using the **freqz()** function in GNU Octave. Four cases were studied, each representing a different filter design with varying numerator and denominator coefficients. For each case, we plotted both the magnitude and phase responses of the system across frequencies. The magnitude plot shows how the filter affects the signal's amplitude, while the phase plot reveals the phase shift introduced by the filter. This lab provided insights into the behavior of filters in both magnitude and phase domains, helping us understand their effects on signals.