Experiment NO: 6

Experiment Name: Implementation of LP FIR Filter

Objective: To implement LP FIR filter for a given sequence.

Theory: FIR filters are digital filters with finite impulse response. They are also known as non-recursive digital filters as they do not have the feedback. An FIR filter has two important advantages over an IIR design: Firstly, there is no feedback loop in the structure of an FIR filter. Due to not having a feedback loop, an FIR filter is inherently stable. Meanwhile, for an IIR filter, we need to check the stability. Secondly, an FIR filter can provide a linear-phase response. As a matter of fact, a linear-phase response is the main advantage of an FIR filter over an IIR design otherwise, for the same filtering specifications; an IIR filter will lead to a lower order.

Window Design Method: In the window design method, one first designs an ideal IIR filter and then truncates the infinite impulse response by multiplying it with a finite length window function. The result is a finite impulse response filter whose frequency response is modified from that of the IIR filter.

Window Name	Transition Approximate	Width $\Delta\omega$ Exact values	Min. Stop band Attenuation	Matlab Command
Rectangular	$\frac{4\Pi}{M}$	$\frac{1.8\Pi}{M}$	21db	B = FIR1(N,Wn,boxcar)
Bartlett	$\frac{8\Pi}{M}$	$\frac{6.1\Pi}{M}$	25db	B = FIR1(N,Wn,bartlett)
Hanning	$\frac{8\Pi}{M}$	$\frac{6.2\Pi}{M}$	44db	B = FIR1(N,Wn,hanning)
Hamming	$\frac{8\Pi}{M}$	$\frac{6.6\Pi}{M}$	53db	B= FIR1(N,Wn,hamming)
Blackman	$\frac{12\Pi}{M}$	$\frac{11\Pi}{M}$	74db	B = FIR1(N,Wn,blackman)

Algorithm:

Step I : Enter the pass band frequency (fp) and stop band frequency (fq).

Step II : Get the sampling frequency (fs), length of window (n).

Step III : Calculate the cut off frequency, fn

Step IV : Use boxcar, hamming, blackman Commands to design window.

Step V : Design filter by using above parameters.

Step VI : Find frequency response of the filter using matlab command freqz.

Step VII : Plot the magnitude response and phase response of the filter.

Program:

```
clc;
clear all;
close all;
n = 20;            % Filter order
fp = 200;          % Passband frequency (Hz)
fq = 300;          % Stopband frequency (Hz)
fs = 1000;         % Sampling frequency (Hz)
fn = fp / (fs / 2);   % Normalized cutoff frequency (0 to 1, where 1 is Nyquist frequency)

% Window function
window = blackman(n + 1);  % Blackman window for filter design
```

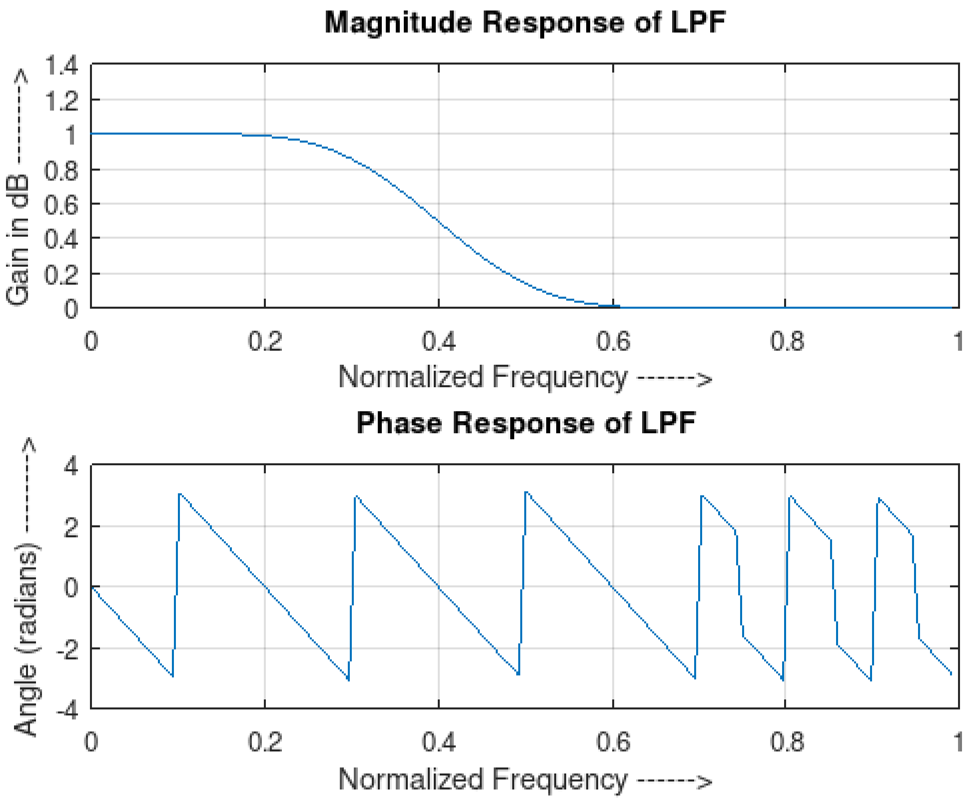
```
b = fir1(n, fn, window);   % Low-pass FIR filter with Blackman window

[H, W] = freqz(b, 1, 128, fs);  % Frequency response with 128 points and sampling frequency fs

subplot(2, 1, 1);
plot(W / (fs / 2), abs(H));   % Normalize frequency to [0, 1]
title('Magnitude Response of LPF');
ylabel('Gain in dB -------->');
xlabel('Normalized Frequency ------>');
grid on;

subplot(2, 1, 2);
plot(W / (fs / 2), angle(H));  % Normalize frequency to [0, 1]
title('Phase Response of LPF');
ylabel('Angle (radians) -------->');
xlabel('Normalized Frequency ------>');
grid on;
```

Output:



Discussion: In this lab, we explored the design and analysis of a low-pass FIR filter using different windowing techniques. The filter's frequency response was analyzed for various windows such as Blackman, and we examined both the magnitude and phase responses. The magnitude response shows how the filter attenuates or passes different frequencies, while the phase response reveals the phase shift introduced by the filter. By using various window functions, we can observe how they affect the filter's performance in terms of ripples, transition width, and overall frequency response. This lab helped us understand the importance of windowing in filter design and its impact on the filter's characteristics.