Experiment - 6 **Date - 15 / 3 / 24**

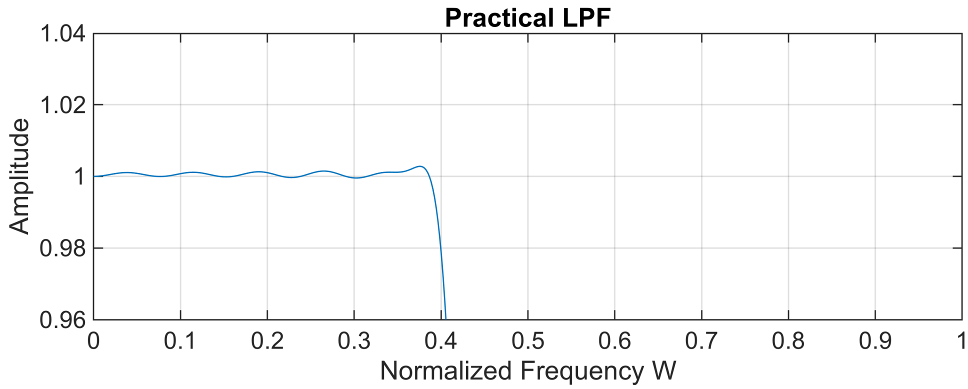
Aim - Design the Finite Impulse Response (FIR) digital filters for low pass , high pass , band pass , and band stop responses.

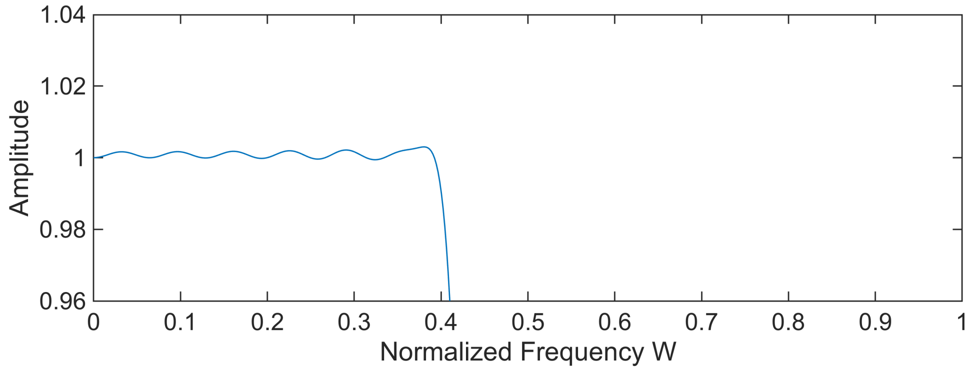
Laboratory Exercise

A) Using the function fir1() , design a linear - phase FIR lowpass filter meeting the specifications : - passband edge = 2kHz , stopband edge = 2.5kHz , passband ripple delp = 0.005 , stopband ripple dels = 0.005 , and sampling rate of 10kHz .

Show the filter coefficients in a tabular form . Does your design meet the specifications ? If it does not , adjust the filter order until the design meets specifications . Based on the results , comments upon the frequency response for chosed order of filter .

```
%[n,Wn,beta,ftype] = kaiserord(f,a,dev)
% fsamp = 8000;
% fcuts = [1000 1500];
% mags = [1 0];
% devs = [0.05 0.01];
%
% [n,Wn,beta,ftype] = kaiserord(fcuts,mags,devs,fsamp);

clc ; clear all ; close all ;

Wp = 2000 ; Ws = 2500 ; delp = 0.005 ; dels = 0.005 ; fs = 10000 ;
fcuts = [Wp Ws] ; mags = [1 0] ; devs = [delp dels] ;
[N , Wn] = kaiserord(fcuts , mags , devs , fs) ;

b = fir1(N , Wn) ;
[H,W] = freqz(b,1) ; grid on ; subplot(2,1,1) ; plot(W/pi , abs(H)) ;
title("Practical LPF") ;  ylabel("Amplitude") ; xlabel("Normalized Frequency W") ;
axis([0 1 0.96 1.04]) ;

%Check for N = 44 and 60 as N = 54
b = fir1(60 , Wn) ;
[H,W] = freqz(b,1) ; grid on ; title("Practical LPF") ; subplot(2,1,2) ;
plot(W/pi , abs(H)) ; ylabel("Amplitude") ; xlabel("Normalized Frequency W") ;
axis([0 1 0.96 1.04]) ;
```



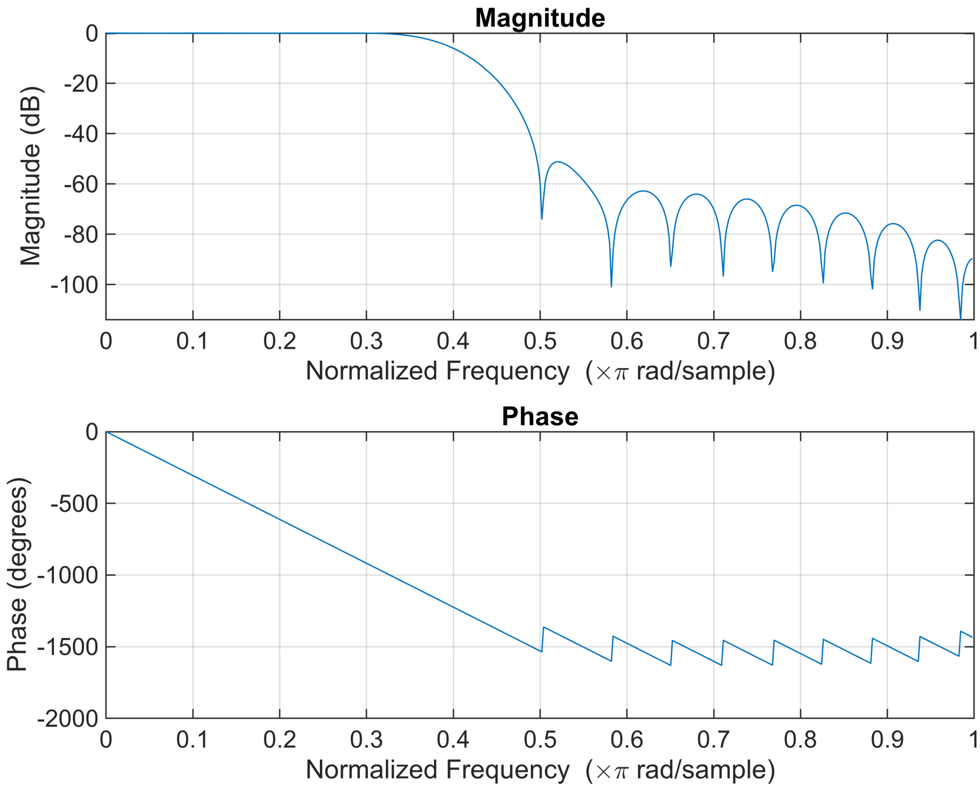


Inference : - Here , we learnt to use kaiserord() and fir1() functions . We learnt how practical or FIR Low Pass Filter is designed in MATLAB . We also found that N = 54 (Order) , and tried to increase the order manually to get near to the requirement specified .We also checked the validity of the filter using data tips . Further increase in the order will take us near to the ideal response but on the cost of increase in Hardware required .

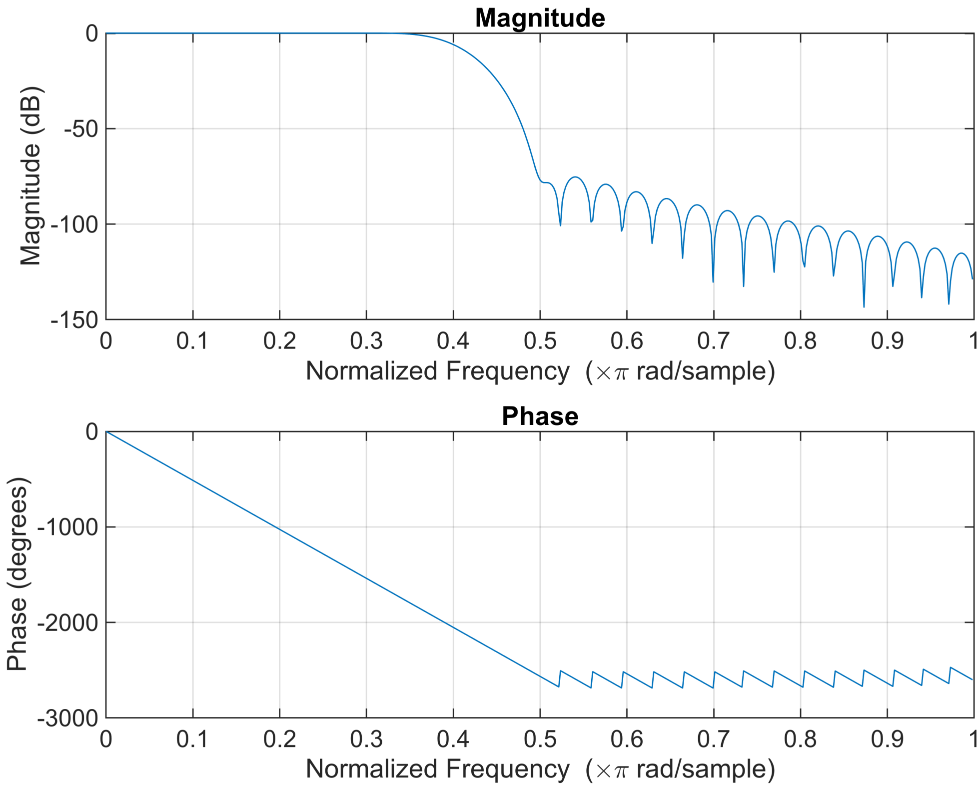
B) One of the techniques to realize FIR Filter is windowing method . In literature , various windows formulation have been proposed . However , the choice of a window is crucial in filter design . Frequency resolution , relative sidelobe attenuation , and transition bandwidth are key factors to choose window for filtering . Using MATLAB , realize the popular windows like rectangular , Barlett , Blackmann , Hamming , Hanning and estimate order of the filter for given specifications for each window : passband edge frequency = 0.3 pi , stopband edge frequency = 0.5 pi , passband attenuation ap = 1dB , and stopband attenuation as = 40dB .

Which window is suitable to realize the given filter specifications ?? Why ??

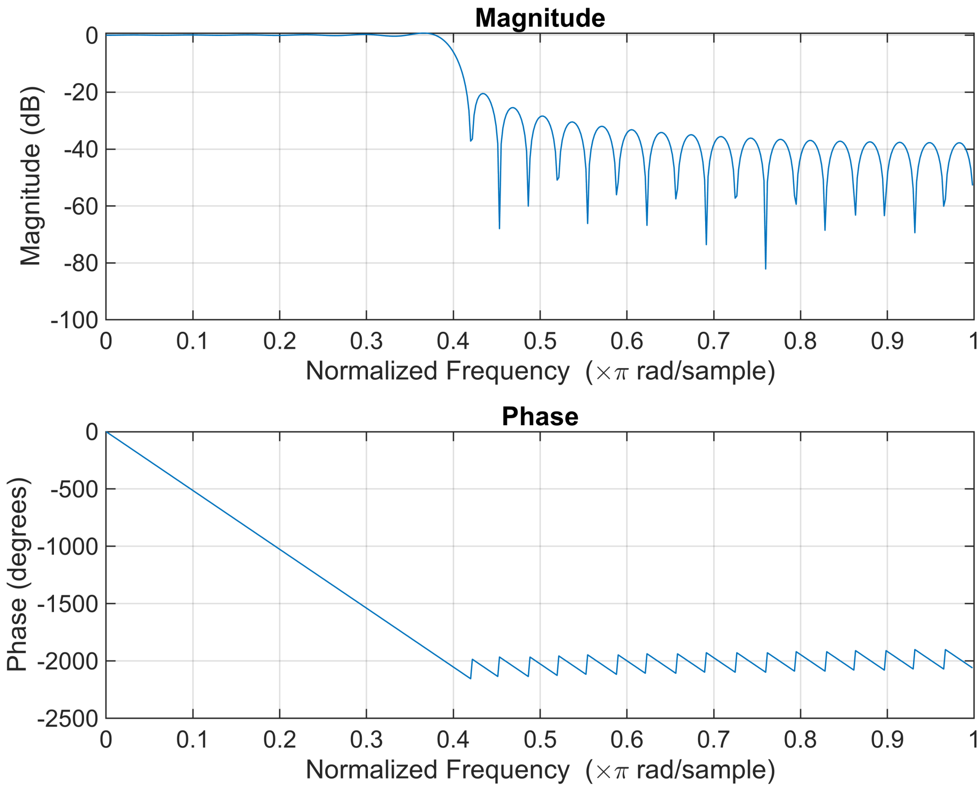
```
clc ; clear all ; close all ;

% Hamming Window
Wp = 0.3 * pi ; Ws = 0.5 * pi ; ap = 1 ; as = 40 ; dw = Ws - Wp ; m1 = 16.6 ;
n1 = round(2 * m1 + 1) ; Wn = (Wp + Ws) / (2 * pi) ;
b1 = fir1(n1 , Wn , hamming(n1 + 1) ) ;
freqz(b1 , 1) ;
```




```
% Blackman Window
Wp = 0.3 * pi ; Ws = 0.5 * pi ; ap = 1 ; as = 40 ; dw = Ws - Wp ;
m2 = 5.56 / 0.2 ; n2 = round(2 * m2 + 1) ; Wn = (Wp + Ws) / (2 * pi) ;
b2 = fir1(n2 , Wn , blackman(n2 + 1) ) ; subplot(3,1,2) ;
freqz(b2 , 1) ;
```




```
% Rectangular Window
Wp = 0.3 * pi ; Ws = 0.5 * pi ; ap = 1 ; as = 40 ; dw = Ws - Wp ;
m3 = 0.92 / 0.2 ; n3 = round(2 * m2 + 1) ; Wn = (Wp + Ws) / (2 * pi) ;
b3 = fir1(n2 , Wn , rectwin(n3 + 1) ) ; subplot(3,1,3) ;
freqz(b3 , 1) ;
```



Inference :- Here , we identified different types of Filter Window and used them to see their responses . We concluded two parameters that are important for Filter Window Selection that are Relative Sidelobe Attenuation and Mainlobe Width . According to better Relative Sidelobe Attenuation we see that Blackmann Window has the highest and can be considered for implementation . According to the Mainlobe Width we see that Rectangular Window has the lowest and can be considered for implementation .

Conclusion :- The experiment on FIR Filter design includes various Window Functions which helps us know the importance of Window Selection on Filter Performance . We also learnt about different parameters related to Windows and how we can select them according to our design and what is the need of such parameters .