DSAP LAB6   075BCT092

Problems:

1. Design an FIR linear phase digital filter approximating the ideal frequency response

$$H(w) = 1, \text{ for } |w| \le \pi/6$$
$$0, \text{ for } \pi/6 < |w| \le \pi$$

a. Plot the window function for Hamming and its frequency response for length of M=31.

b. Using the Hamming window plot the frequency response of the truncated FIR filter.

c. Repeat parts (a) and (b) for the Hanning, Blackman and Bartlett windows.

d. Repeat parts (a), (b) and (d) for filter length of M=61.

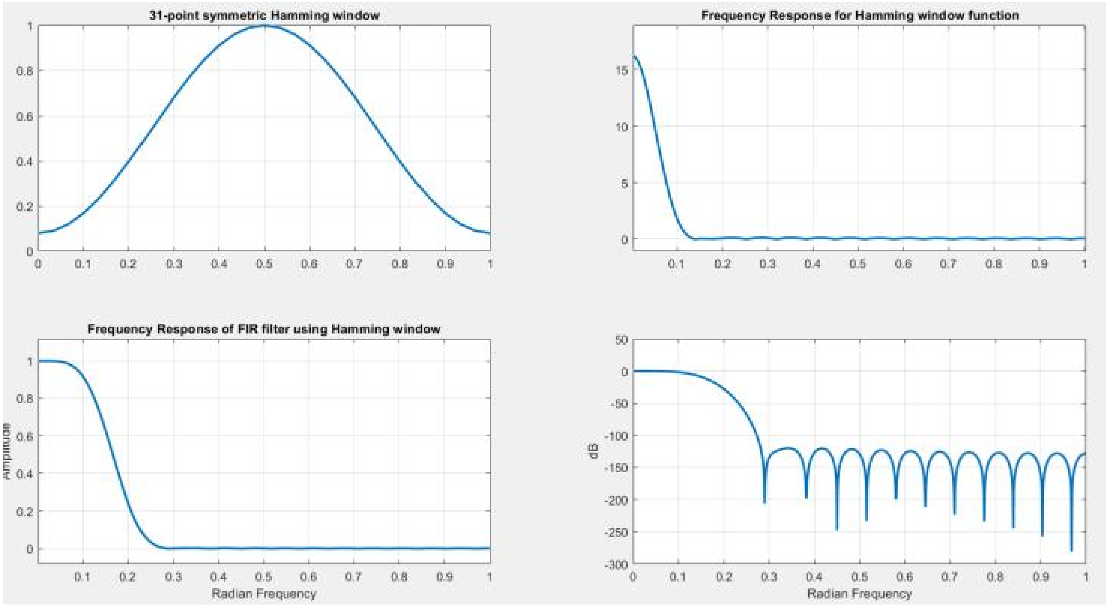
Code :

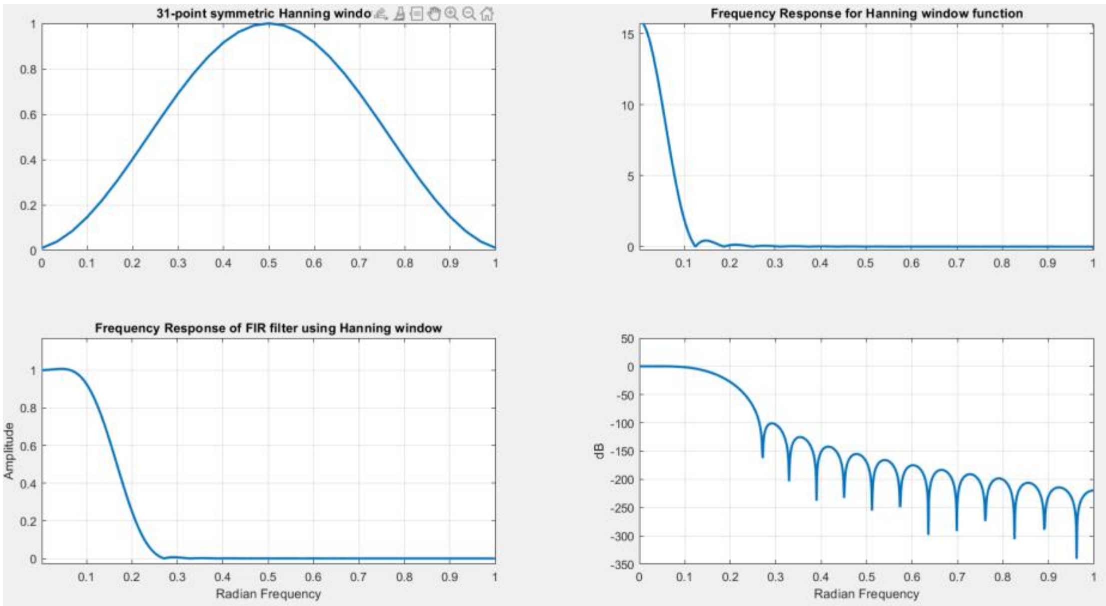
```
%a
f = [0 pi/6 pi/6 pi];
H = [1 1 0 0];
M = 31;
w = 0:pi/30:pi;
subplot(2,2,1);
h = hamming(M);
plot(w/pi,h,'linewidth', 2);
grid on;
title('31-point symmetric Hamming window');
subplot(2,2,2);
[H1,w] = freqz(h,1,1024);
plot(w/pi,abs(H1),'linewidth', 2);
grid on;
title('Frequency Response for Hamming window function');
subplot(2,2,3);
B = fir1(M-1,1/6,h); %It uses Hamming window of length M+1 by default
if not specified
[H2,w] = freqz(B,1,1024);
plot(w/pi,abs(H2),'linewidth', 2);
grid on;
ylabel('Amplitude');
xlabel('Radian Frequency');
title('Frequency Response of FIR filter using Hamming window');
gk = 20*log(abs(H2));
subplot(2,2,4);
plot(w/pi,gk,'linewidth', 2);
grid on;
ylabel('dB');
xlabel('Radian Frequency');

%b
w = 0:pi/30:pi;
figure(2);
h = hanning(M);
subplot(2,2,1);
plot(w/pi,h,'linewidth', 2);
title('31-point symmetric Hanning window');
grid on;
```

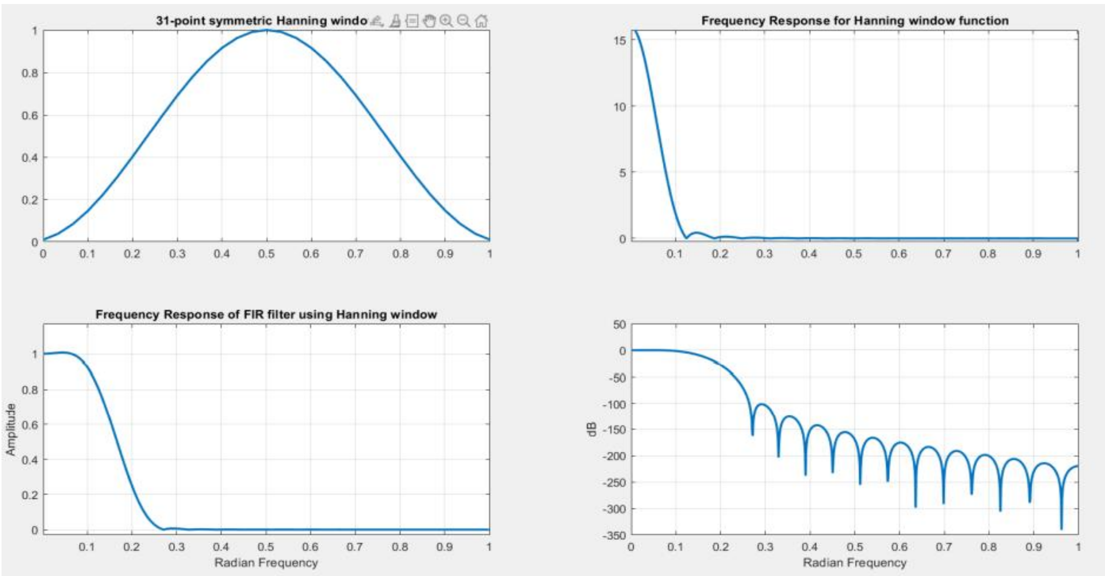
```
subplot(2,2,2);
[H1,w] = freqz(h,1,1024);
plot(w/pi,abs(H1),'linewidth', 2);
title('Frequency Response for Hanning window function');
grid on;
subplot(2,2,3);
B = fir1(M-1,1/6,h); %It uses Hamming window of length M+1 by default
[H2,w] = freqz(B,1,1024);
plot(w/pi,abs(H2),'linewidth', 2);
grid on;
ylabel('Amplitude');
xlabel('Radian Frequency');
title('Frequency Response of FIR filter using Hanning window');
gk = 20*log(abs(H2));
subplot(2,2,4);
plot(w/pi,gk,'linewidth', 2);
grid on;
ylabel('dB');
xlabel('Radian Frequency');

%c
w = 0:pi/30:pi;
figure(3);
subplot(2,2,1);
h = blackman(M);
plot(w/pi,h,'linewidth', 2);
grid on;
title('31-point symmetric Blackman window');
subplot(2,2,2);
[H1,w] = freqz(h,1,1024);
plot(w/pi,abs(H1),'linewidth', 2);
grid on;
title('Frequency Response for Blackman window function');
subplot(2,2,3);
B = fir1(M-1,1/6,h); %It uses Hamming window of length M+1 by default
[H2,w] = freqz(B,1,1024);
plot(w/pi,abs(H2),'linewidth', 2);
grid on;
ylabel('Amplitude');
xlabel('Radian Frequency');
title('Frequency Response of FIR filter using Blackman window');
gk = 20*log(abs(H2));
subplot(2,2,4);
plot(w/pi,gk,'linewidth', 2);
grid on;
ylabel('dB');
xlabel('Radian Frequency');

w = 0:pi/30:pi;
figure(4);
subplot(2,2,1);
h = bartlett(M);
plot(w/pi,h,'linewidth', 2);
grid on;
title('31-point Bartlett window');
subplot(2,2,2);
[H1,w] = freqz(h,1,1024);
```

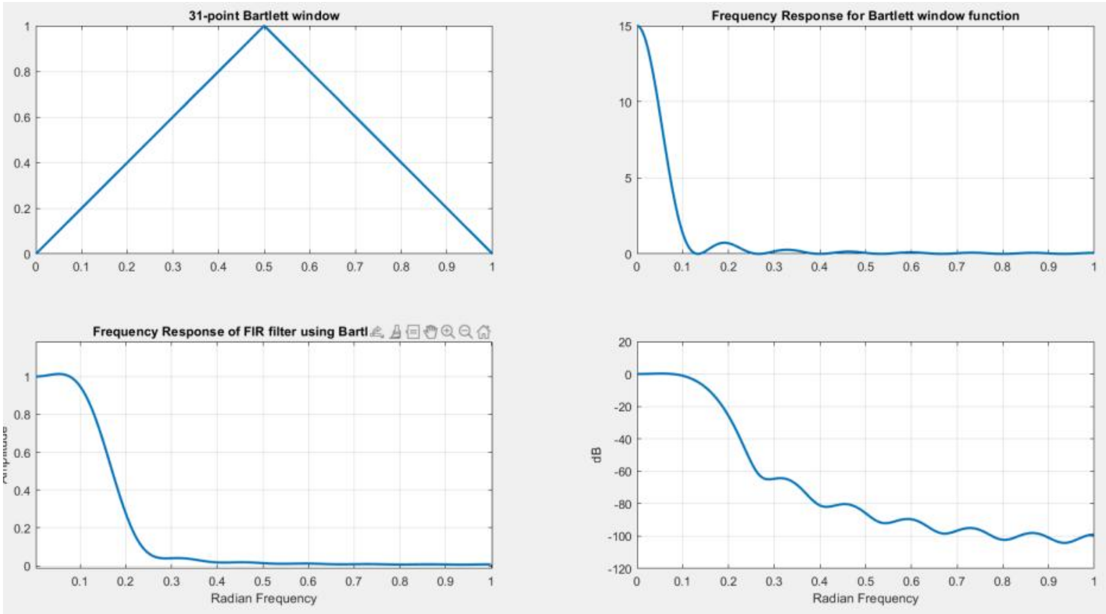
```
plot(w/pi,abs(H1),'linewidth', 2);
grid on;
title('Frequency Response for Bartlett window function');
subplot(2,2,3);
B = fir1(M-1,1/6,h); %It uses Hamming window of length M+1 by default
[H2,w] = freqz(B,1,1024);
plot(w/pi,abs(H2),'linewidth', 2);
grid on;
ylabel('Amplitude');
xlabel('Radian Frequency');
title('Frequency Response of FIR filter using Bartlett window');
gk = 20*log(abs(H2));
subplot(2,2,4);
plot(w/pi,gk,'linewidth', 2);
grid on;
ylabel('dB');
xlabel('Radian Frequency');

%d
figure(5);
M = 61;
w = 0:pi/60:pi;
subplot(2,2,1);
h = hamming(M);
plot(w/pi,h,'linewidth', 2);
grid on;
title('61-point symmetric Hamming window');
subplot(2,2,2);
[H1,w] = freqz(h,1,1024);
plot(w/pi,abs(H1),'linewidth', 2);
grid on;
title('Frequency Response for Hamming window function');
subplot(2,2,3);
B = fir1(M-1,1/6,h);%It uses Hamming window of length M+1 by default
[H2,w] = freqz(B,1,1024);
plot(w/pi,abs(H2),'linewidth', 2);
grid on;
ylabel('Amplitude');
xlabel('Radian Frequency');
title('Frequency Response of FIR filter using Hamming window');
gk = 20*log(abs(H2));
subplot(2,2,4);
plot(w/pi,gk,'linewidth', 2);
grid on;
ylabel('dB');
xlabel('Radian Frequency');
end
```

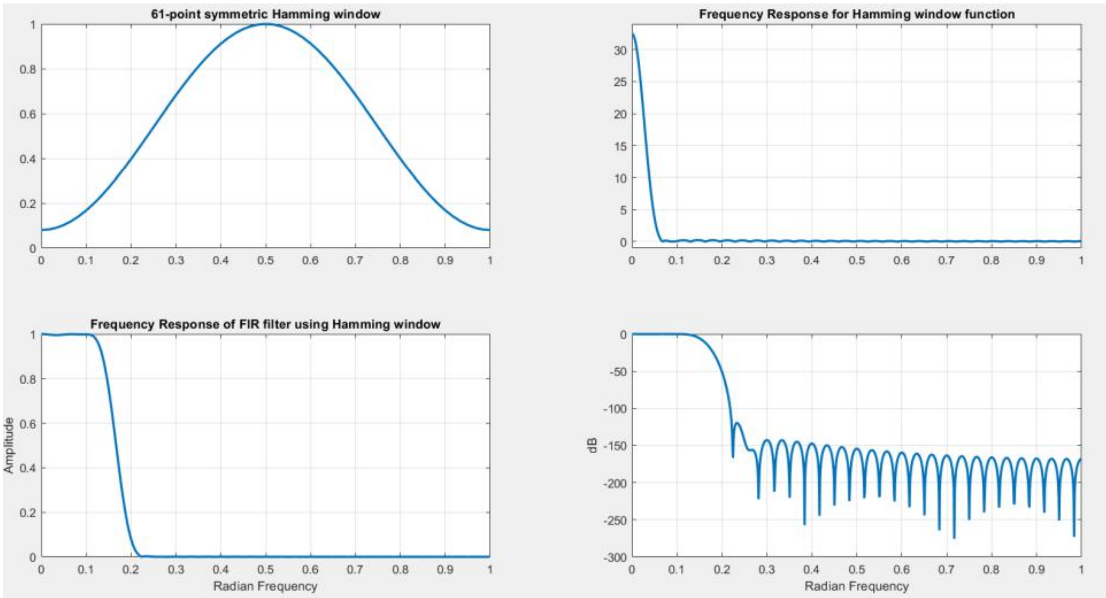
Output:


31-point symmetric Hamming window
Frequency Response for Hamming window function
Frequency Response of FIR filter using Hamming window
Amplitude
Radian Frequency
dB
Radian Frequency


31-point symmetric Hanning windo
Frequency Response for Hanning window function
Frequency Response of FIR filter using Hanning window
Amplitude
Radian Frequency
dB
Radian Frequency


31-point symmetric Hanning windo
Frequency Response for Hanning window function
Frequency Response of FIR filter using Hanning window
Amplitude
Radian Frequency
dB
Radian Frequency

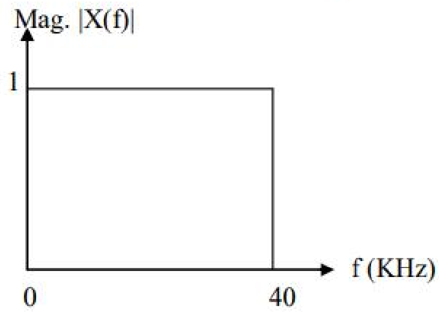




2. Discuss the effects of different types of the windowing functions on the frequency response of the FIR filter. Carry out the comparative study on the basis of the peak side-lobe level, the approximate transition width of the main lobe etc. Also discuss on the effects of increasing value of M.

Ans: In 4th figure above the frequency response of every FIR filter using different window function is shown in the log magnitude form. The fourier transforms is concentrated around w = 0. In consideration of Hamming, Hanning , Bartlett and Blackman windows, the frequency response using the Blackman window has the largest main lobe width about 12 * pie/31 and has the largest transition width for a given length. When tapering the window to zero , as with Hamming, Bartlett and Hanning and Blackman , the side lobes are greatly reduced in amplitude, however the price paid is a much wider main lobe. By increasing M, the area under each lobe remains constant and thus results in non-uniform convergence known as the GIbbs phenomenon.

3. An analog signal x(t) consists of the sum of two components $x_1(t)$ and $x_2(t)$. The spectral characteristics of x(t) is shown in fig 2.1. The signal x(t) is band limited to 40kHz and is sampled at the rate of 100kHz to yield the sequence x(n) .



It is desired to suppress the signal $x_2(t)$ by passing the sequence x(n) through a digital low pass filter. The allowable distortion on $|X_1(f)|$ is ±2% (δ_1=0.02) over the range $0 \leq |F| \leq 15$ kHz. Above 20 kHz, the filter must have an attenuation of at least 40 dB (δ_2=0.01).

a. For obtaining the filter with above specifications, use the Kaiser window and determine the length of the required window. Plot the frequency response of the filter and its impulse response also.

b. If the same filter is to be designed using Hamming window what would be the length of the required window. Plot the frequency and impulse response of the filter.

Code:

```
wsample = 100;
wp = 15;
ws = 20;
wpn = 2*wp/wsample;
wsn = 2*ws/wsample;
wn = (wpn + wsn)/2;
Rs = 40;
beta = 0.5842.*(Rs-21)^0.4+0.07886.*(Rs-21);
dw = (wsn - wpn)/2;
M = ((Rs-7.95)./(14.36*dw)) + 1;
N = round(M);
Kaiser_window_length = N
wk = kaiser(N,beta);
bk = fir1(N-1,wn,wk);
[H,w] = freqz(bk,1,512);
subplot(2,1,1);
plot(w/pi,abs(H), 'linewidth', 2);
title('Frequency Response of FIR filter using Kaiser Window');
grid on;
subplot(2,1,2);
plot(w/pi,20*log10(abs(H)), 'linewidth', 2);
xlabel('radian frequency');
ylabel('dB');
grid on;
figure('Name','impulse response');
nk = 0:N-1;
```

dimpulse(nk,bk);
title('Impulse Response of the FIR filter');
grid on;

Output:

```
>> q3

Kaiser_window_length = 46
```