Digital Signal Processing
MATLAB HW3 - q1

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Clear recent data

```
clear; close all; clc;
```

FIR Filter Design

A. Windowing

Part 1

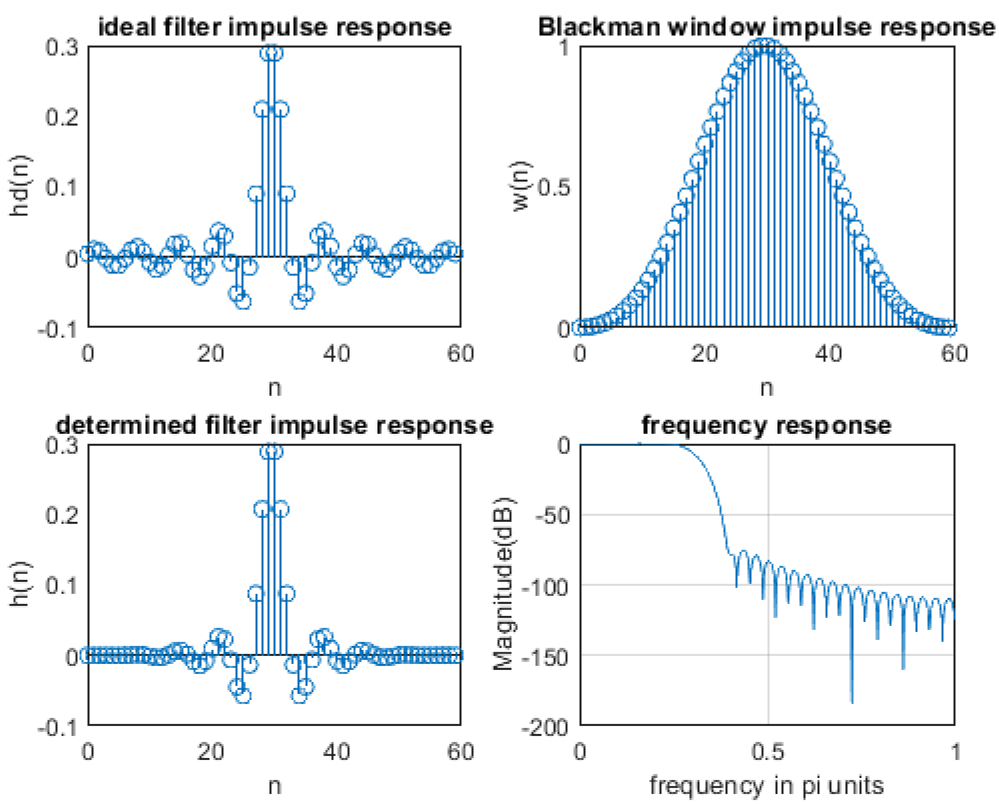
```
% define parameters
wp = 0.2*pi;                    % passband frequency
ws = 0.4*pi;                    % stopband frequency
wc = (wp + ws)/2;               % cutoff frequency
```

Blackman

since As = 60 dB we use * Blackman * filter (-74 dB)

```
M_b = 60 ;                        % M = (12*pi)/(0.2*pi)
n = 0:1:M_b-1 ;
hd_b = ideal_lp(wc,M_b);        % ideal lowpass define for
 blackman
w_bl = (blackman(M_b))';        % blackman window define with
 lenght M
h_b = hd_b .* w_bl;             % FIR Blackman filter

% frequency responce
[h1,w] = freqz(h_b,1);

% Plot
figure(1);
subplot(2,2,1);
```

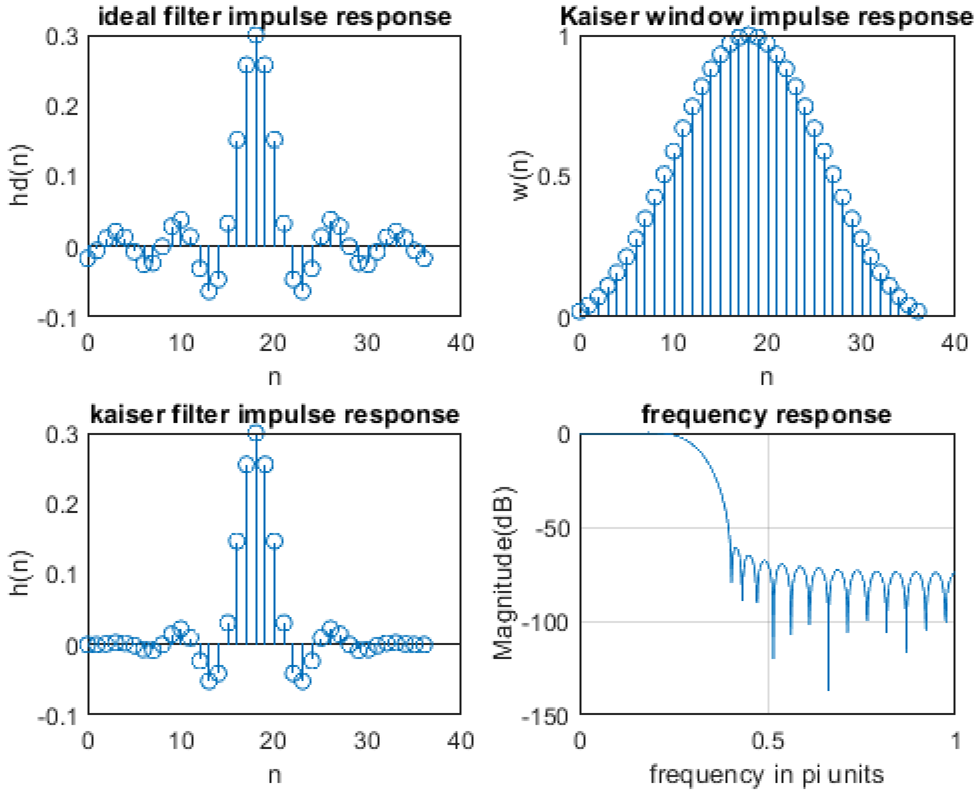
```
stem(n,hd_b);
title("ideal filter impulse response");
xlabel('n');
ylabel('hd(n)')
subplot(2,2,2);
stem(n,w_bl);
title("Blackman window impulse response");
xlabel('n');
ylabel('w(n)');
subplot(2,2,3);
stem(n,h_b);
title("determined filter impulse response");
xlabel('n');
ylabel('h(n)');
subplot(2,2,4);
plot(w/pi,20*log10(abs(h1)));
title("frequency response");
xlabel('frequency in pi units');
ylabel('Magnitude(dB)');
grid;

% Obtain The final value of Rp and As
delta_w1 = 2*pi/1000;
db = 20*log10((abs(h1)+eps)/max(abs(h1)));
Rp_blackman = -(min(db(1:1:wp/delta_w1+1)));
As_blackman = -round(max(db(ws/delta_w1+1:1:501)));
```



B.Kaiser

Part 2

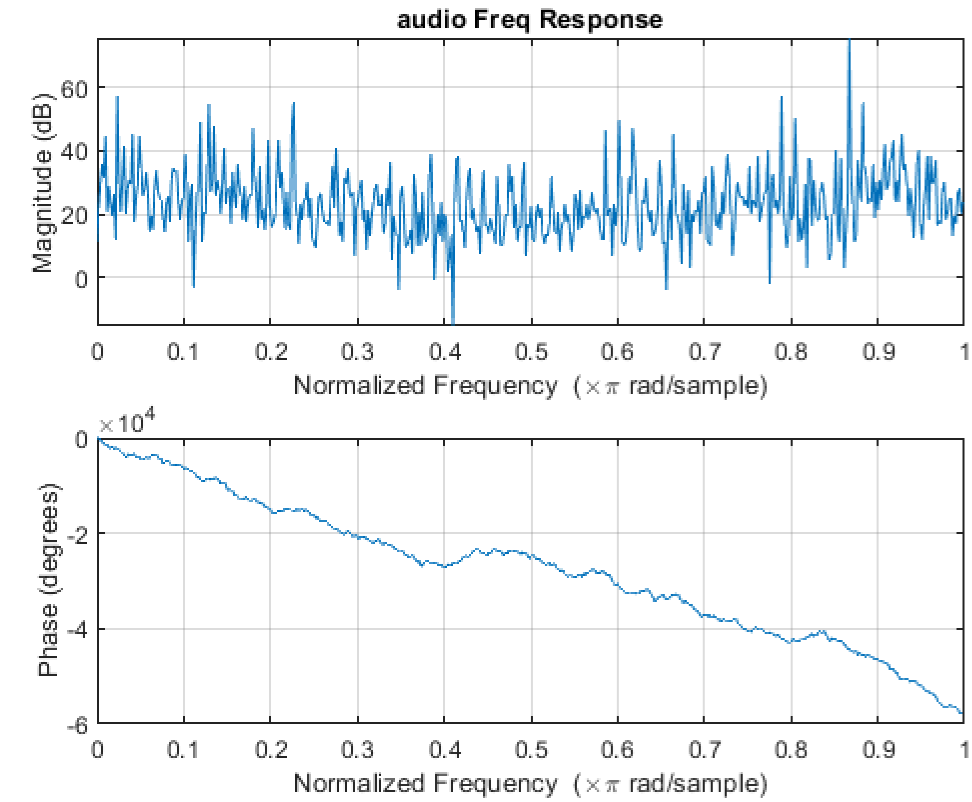
```
As = 60;
beta = 0.1102*(As-8.7);                      % beta = 5.6533
delta_w = ws - wp;
M_k = round((As-7.95)/(2.285*delta_w)) +1;   % M = 37
n_k=[0:1:M_k-1];
hd_k = ideal_lp(wc,M_k);                  % ideal lowpass define for
 kaiser
w_kai = (kaiser(M_k,beta))';              % kaiser window with lenght
 M
h_k = hd_k .* w_kai;                      % kaiser filter

% frequency responce
[h2,w] = freqz(h_k,1);

% Plot
figure(2);
subplot(2,2,1);
stem(n_k,hd_k);
title("ideal filter impulse response");
xlabel('n');
ylabel('hd(n)')
subplot(2,2,2);
stem(n_k,w_kai);
title("Kaiser window impulse response");
xlabel('n');
ylabel('w(n)');
subplot(2,2,3);
stem(n_k,h_k);
title("kaiser filter impulse response");
xlabel('n');
ylabel('h(n)');
subplot(2,2,4);
plot(w/pi,20*log10(abs(h2)));
title("frequency response");
xlabel('frequency in pi units');
ylabel('Magnitude(dB)');
grid;

% Obtain The final value of Rp and As
delta_w1 = 2*pi/1000;
db2 = 20*log10((abs(h2)+eps)/max(abs(h2)));
Rp_kaiser = -(min(db2(1:1:wp/delta_w1+1)));
As_kaiser = -round(max(db2(ws/delta_w1+1:1:501)));
```

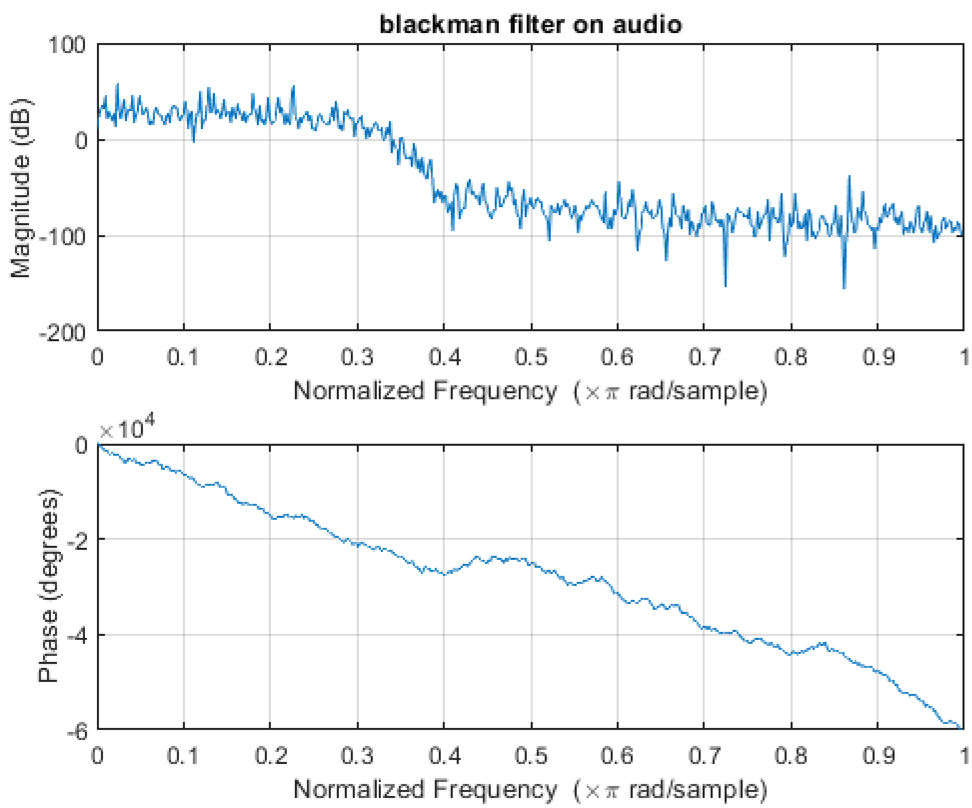


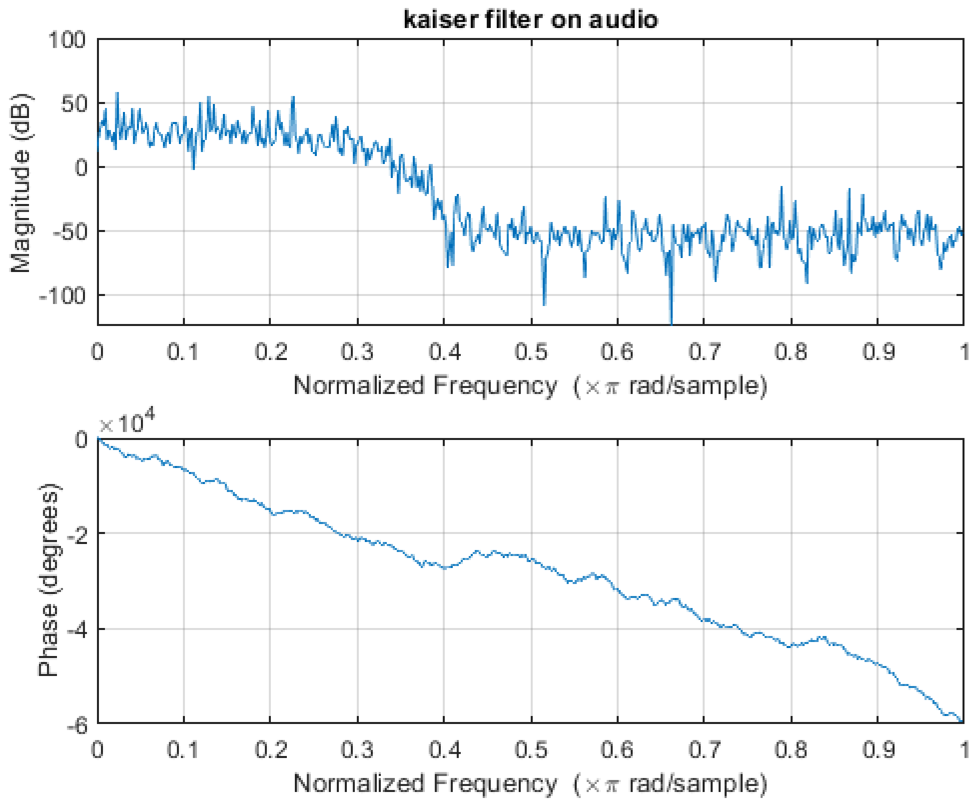
C.Filtering

Part 3

```
[audio , Fs] = audioread('HW3_Q1_multi_tone.wav');
audio = audio' ;

figure(3);
freqz(audio);
title('audio Freq Response');

% Put blackman filter on audio
audio_bl = conv(audio , h_b);
figure(4);
freqz(audio_bl);
title('blackman filter on audio');

% Put Kaiser filter on audio
audio_k = conv(audio , h_k);
figure(5);
freqz(audio_k);
title('kaiser filter on audio');
```


audio Freq Response
Magnitude (dB)
60
40
20
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)
×10^4
0
-2
-4
-6
Phase (degrees)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)


blackman filter on audio
Magnitude (dB)
100
0
-100
-200
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)
×10^4
0
-2
-4
-6
Phase (degrees)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)



Ideal Low pass Design %%

```
function [hd] = ideal_lp(wc,M)
n = [0:1:(M-1)];
alpha = (M-1)/2;
m = n- alpha;
fc = wc/pi;
hd = fc*sinc(fc*m);
end
```

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