Hacettepe University

Department of Electrical and Electronics Engineering

ELE 409 Digital Signal Proccessing Laboratory

# EXPERIMENT 4 – FIR FILTER

## PRELIMINARY WORK

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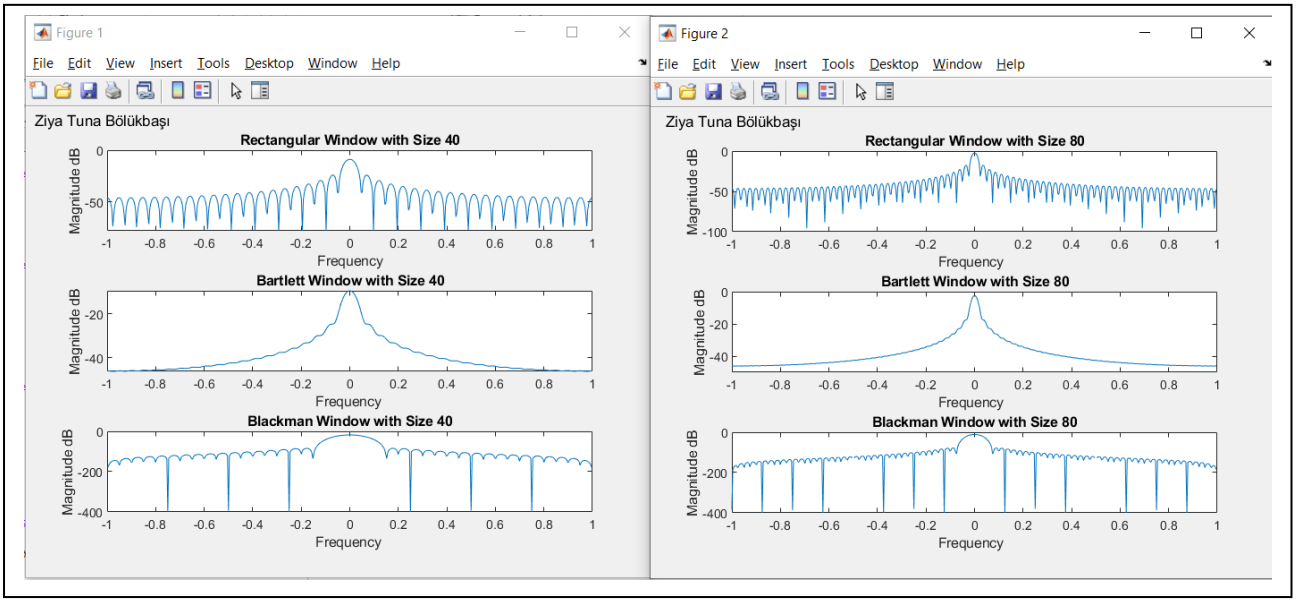
# 1)Matlab Code

```
clc;
clear all;
close all;
function w=rec(M)
n=0:1:M;
w=ones(1,length(n));
end
function w=bart(M)
w=zeros(1,M+1);
mid=floor((M+1)/2);
n=0:1:M;
w(1:mid)=2*n(1:mid)/M;
w(mid+1:end)=2-2*n(mid+1:end)/M;
end
function w=bla(M)
n=0:1:M;
w=0.42-0.5*cos(2*pi*n/M)+0.08*cos(4*pi*n/M);
end
```

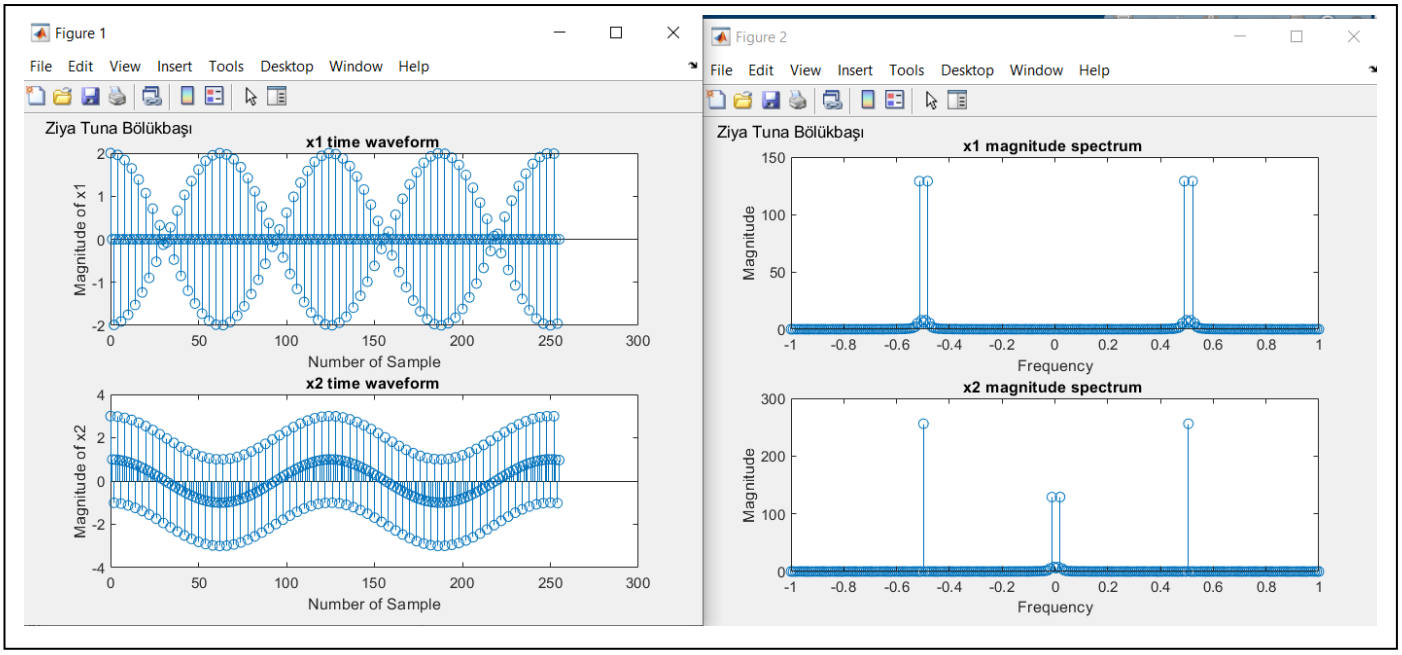
# 2)Matlab Code

```
rec40=rec(40);
[h, w] = freqz(rec40,100,'whole');
h=circshift(h,length(h)/2);
figure,subplot(3,1,1)
y=-1:2/length(h):1-1/length(h)
x=10*log(abs(h))
plot(y,x)
title('Rectangular Window with Size 40'),xlabel('Frequency'), ylabel('Magnitude dB')
bart40=bart(40);
[h, w] = freqz(bart40,100,'whole');
h=circshift(h,length(h)/2);
subplot(3,1,2)
y=-1:2/length(h):1-1/length(h)
x=10*log(abs(h))
plot(y,x)
title('Bartlett Window with Size 40'),xlabel('Frequency '), ylabel('Magnitude dB')
bla40=bla(40);
[h, w] = freqz(bla40,100,'whole');
h=circshift(h,length(h)/2);
subplot(3,1,3)
y=-1:2/length(h):1-1/length(h)
x=10*log(abs(h))
plot(y,x)
title('Blackman Window with Size 40'),xlabel('Frequency '), ylabel('Magnitude dB')
rec80=rec(80);
[h, w] = freqz(rec80,100,'whole');
h=circshift(h,length(h)/2);
gtext('Ziya Tuna Bölükbaşı')
figure,subplot(3,1,1)
y=-1:2/length(h):1-1/length(h)
x=10*log(abs(h))
plot(y,x)
title('Rectangular Window with Size 80'),xlabel('Frequency  '), ylabel('Magnitude dB')
bartWinSize80=bart(80);
[h, w] = freqz(bartWinSize80,100,'whole');
h=circshift(h,length(h)/2);
subplot(3,1,2)
y=-1:2/length(h):1-1/length(h)
x=10*log(abs(h))
plot(y,x)
title('Bartlett Window with Size 80'),xlabel('Frequency  '), ylabel('Magnitude dB')
blaWinSize80=bla(80);
[h, w] = freqz(blaWinSize80,100,'whole');
h=circshift(h,length(h)/2);
subplot(3,1,3)
y=-1:2/length(h):1-1/length(h)
x=10*log(abs(h))
plot(y,x)
title('Blackman Window with Size 80'),xlabel('Frequency  '), ylabel('Magnitude dB')
gtext('Ziya Tuna Bölükbaşı')
```



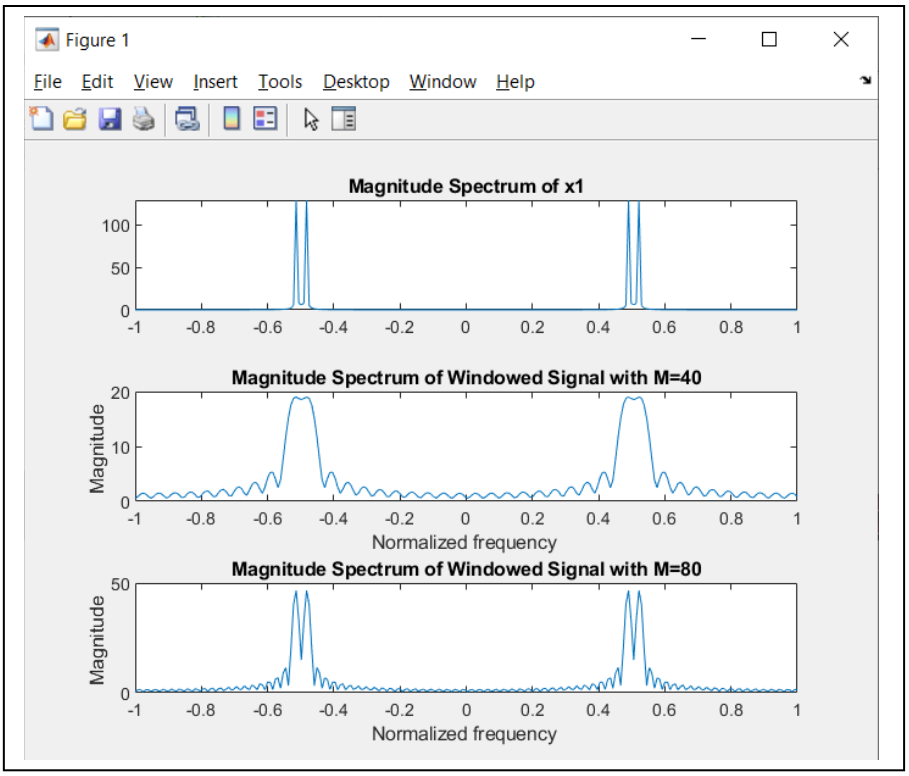

# 3)Matlab Code

```
clc;
clear all;
close all;
n=0:1:255;
x1=cos(2*pi*0.242*n)+cos(2*pi*0.258*n);
x2=2*cos(2*pi*0.25*n)+cos(2*pi*0.008*n);
x3=cos(2*pi*0.29*n);
[lengthx1,fftshift_x1]=mresponse(x1)
[lengthx2,fftshift_x2]=mresponse(x2)
[lengthx3,fftshift_x3]=mresponse(x3)
figure;
subplot(211),stem(n,x1),title('x1 time waveform ');
xlabel('Number of Sample'),ylabel('Magnitude of x1')
subplot(212),stem(n,x2),title('x2 time waveform ');
xlabel('Number of Sample'),ylabel('Magnitude of x2')
freq1=-1:2/(lengthx1-1):1;
freq2=-1:2/(lengthx2-1):1;
figure;
subplot(211),stem(freq1,fftshift_x1),title('x1 magnitude spectrum ');
xlabel('Frequency'),ylabel('Magnitude')
subplot(212),stem(freq2,fftshift_x2),title('x2 magnitude spectrum ');
xlabel('Frequency'),ylabel('Magnitude')
function [length_fftx,fftshift_of_x] = mresponse(in_x)
fft_of_x=fft(in_x)
fftshift_of_x=fftshift(abs(fft_of_x));
length_fftx=length(fftshift_of_x);
end
```




# 4)Matlab Code

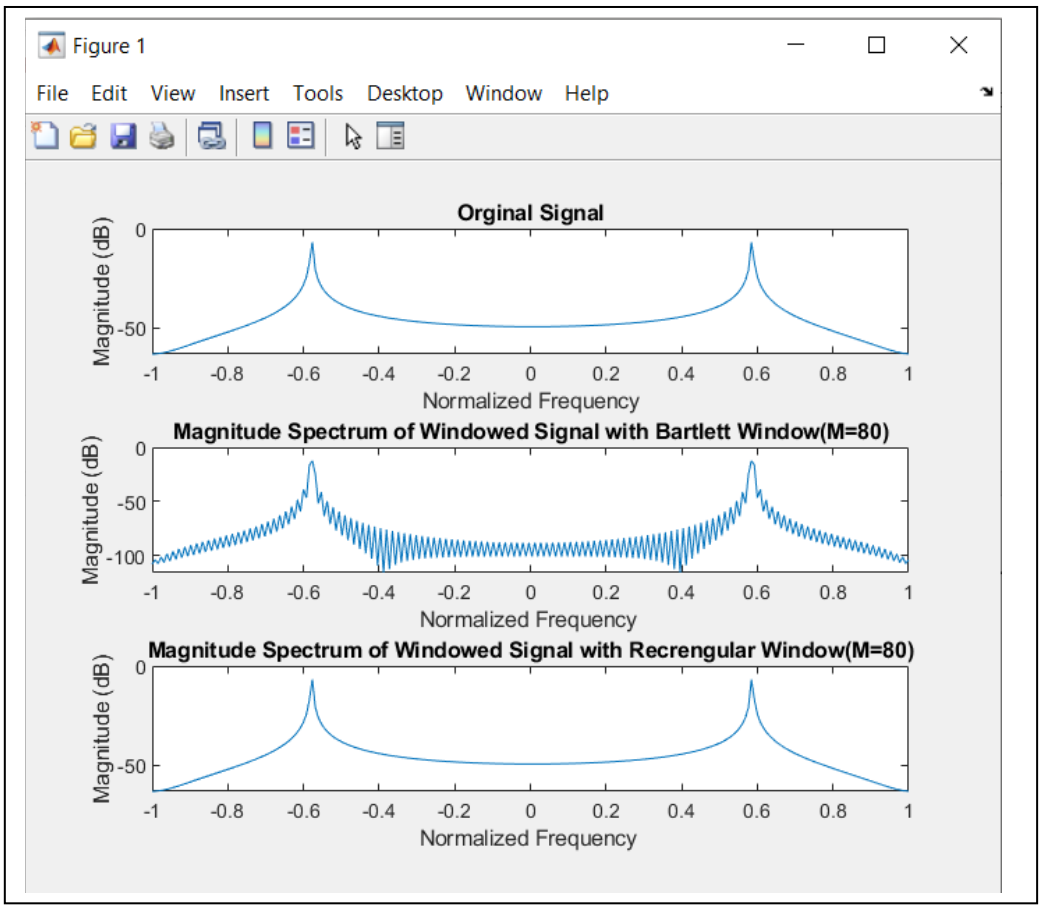
```
clc;
clear all;
close all;
n=0:1:255;
rec1=rec(40);
rec2=rec(80);
x1=cos(2*pi*0.242*n)+cos(2*pi*0.258*n);
x1_window_r1=x1.*[rec1 zeros(1,length(x1)-length(rec1))];
x1_window_r2=x1.*[rec2 zeros(1,length(x1)-length(rec2))];
[freq_x1,fftshift_x1]=mresponse(x1)
[freq_x1r1,fftshift_x1_window_r1]=mresponse(x1_window_r1)
[freq_x1r2,fftshift_x1_window_r2]=mresponse(x1_window_r2)
figure;
subplot(311),plot(freq_x1,fftshift_x1),title('Magnitude Spectrum of x1');
subplot(312),plot(freq_x1r1,fftshift_x1_window_r1),title('Magnitude Spectrum of
Windowed Signal with M=40'),xlabel('Normalized frequency '),ylabel('Magnitude ');
subplot(313),plot(freq_x1r2,fftshift_x1_window_r2),title('Magnitude Spectrum of
Windowed Signal with M=80'),xlabel('Normalized frequency '),ylabel('Magnitude ');
function w=rec(M)
n=0:1:M;
w=ones(1,length(n));
end
function [range_of_frequency,fftshift_of_x] = mresponse(in_x)
fft_of_x=fft(in_x)
fftshift_of_x=fftshift(abs(fft_of_x));
length_fftx=length(fftshift_of_x);
range_of_frequency=-1:2/(length(in_x)-1):1;
end
```




Windowing a signal in the time domain corresponds to convolution in the frequency domain. The larger window size, the better the filter will filter.

# 5)Matlab Code

```
n=0:1:255;
x3=cos(2*pi*0.29*n);
bart1=bart(255);
rec1=rec(255);
x3_window_b=x3.*[bart1 zeros(1,length(x3)-length(bart1))];
x3_window_r=x3.*[rec1 zeros(1,length(x3)-length(rec1))];
[freq1,fftshift_x3,db_x3]=mresponse(x3)
[freq2,fftshift_x3_b,db_x3_b]=mresponse(x3_window_b)
[freq3,fftshift_x3_r,db_x3_r]=mresponse(x3_window_r)
figure;
subplot(311),plot(freq1,db_x3),title('Orginal Signal'),xlabel('Normalized Frequency'),ylabel('Magnitude
(dB)');
subplot(312),plot(freq2,db_x3_b),title('Magnitude Spectrum of Windowed Signal with Bartlett
Window(M=80)'),xlabel('Normalized Frequency '),ylabel('Magnitude (dB)');
subplot(313),plot(freq3,db_x3_r),title('Magnitude Spectrum of Windowed Signal with Recrengular
Window(M=80)'),xlabel('Normalized Frequency '),ylabel('Magnitude (dB)');
function [range_of_frequency,fftshift_of_x,db_x] = mresponse(in_x)
fft_of_x=fft(in_x,length(in_x))
fftshift_of_x=fftshift(abs(fft_of_x));
db_x=20*log10(fftshift_of_x/length(fftshift_of_x))
range_of_frequency=-1:2/(length(db_x)-1):1;
end
function [w]=rec(M) %rectangular window
n=0:1:M;
w=ones(1,length(n)); % M+1 is the length of the window
end
function [w]=bart(M) %bartlett window
w=zeros(1,M+1); % M+1 is the length of the window
mid=floor((M+1)/2);
n=0:1:M;
w(1:mid)=2*n(1:mid)/M;
w(mid+1:end)=2-2*n(mid+1:end)/M;
end
```




Bartlett windowing causes more data loss than rectangular windowing. The rectangular windowed state of the signal is almost equal to itself.

6) 1-They are designed as linear phase

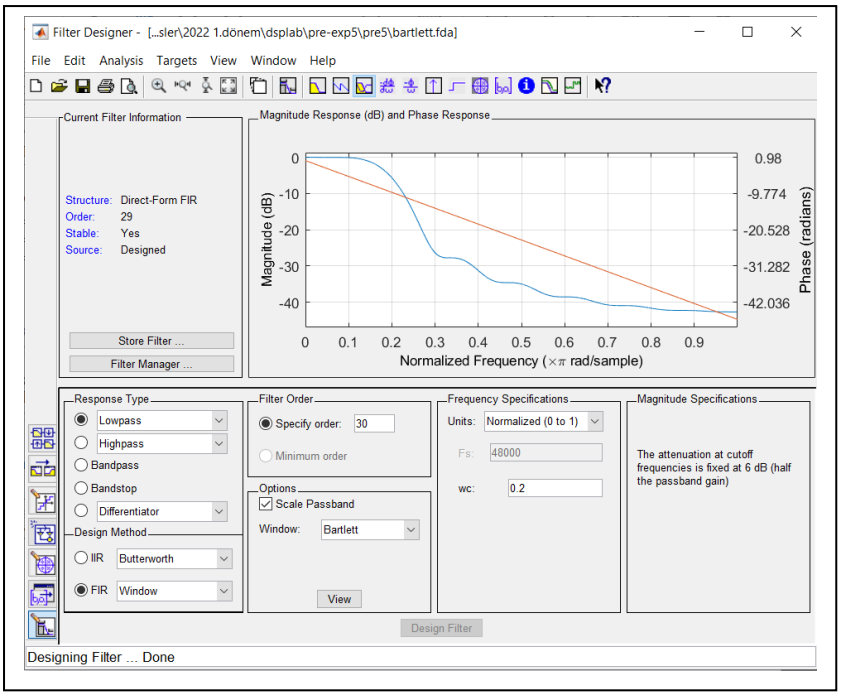
2-Easier to implementation

3-FIR systems can always be designed to provide stable and linear phase response.

A linear phase filter preserves the waveform of the signal and its components.

Phase distortion can cause interference of signals in digital communication applications.

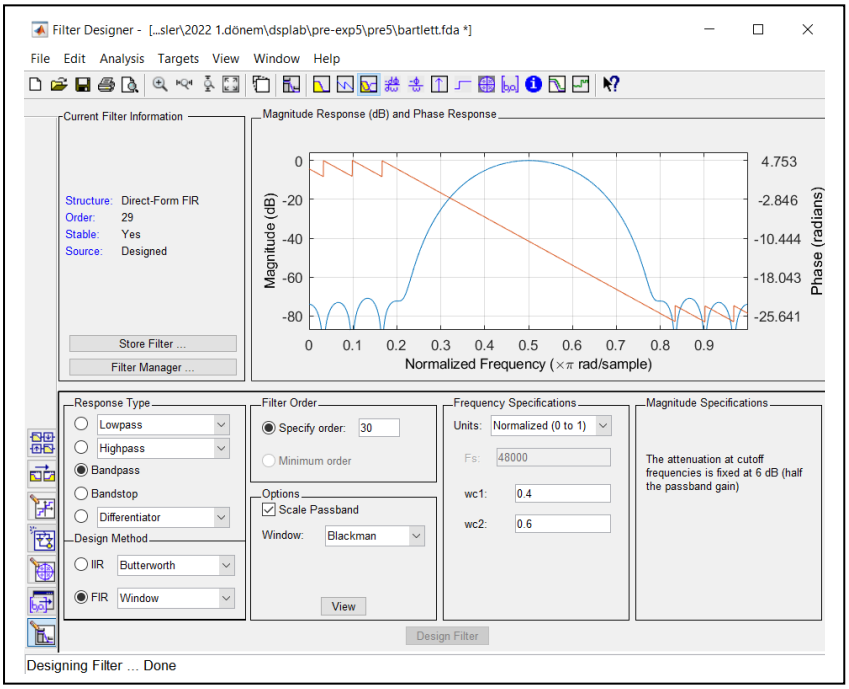
7)




Implementation

b=fir1(30,0.2,'low','scale')

8)




Implementation

b=fir1(30,([0.4 0.6]),'bandpass','scale')