Digital Signal Processing Lab

Experiment 2

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Aim:

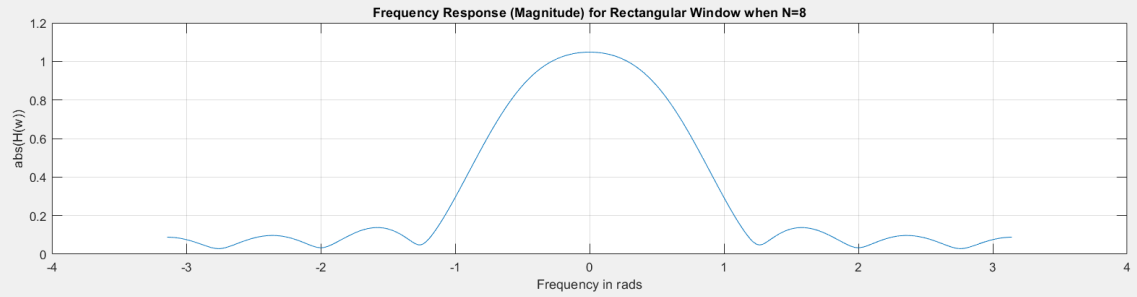
To design various FIR Filters using windowing

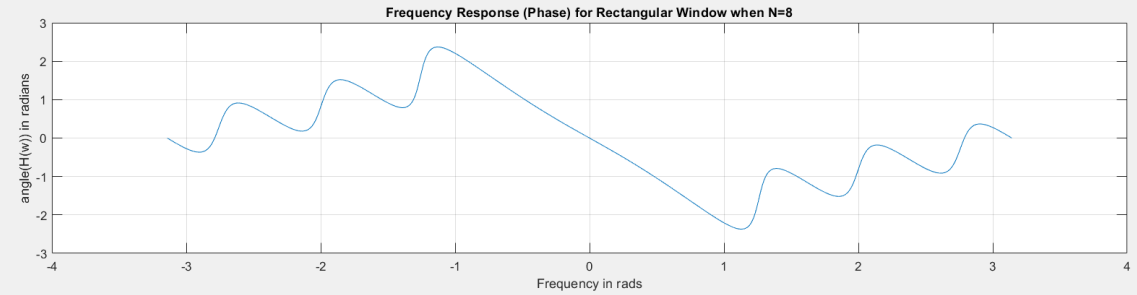
To check whether the filter works as desired

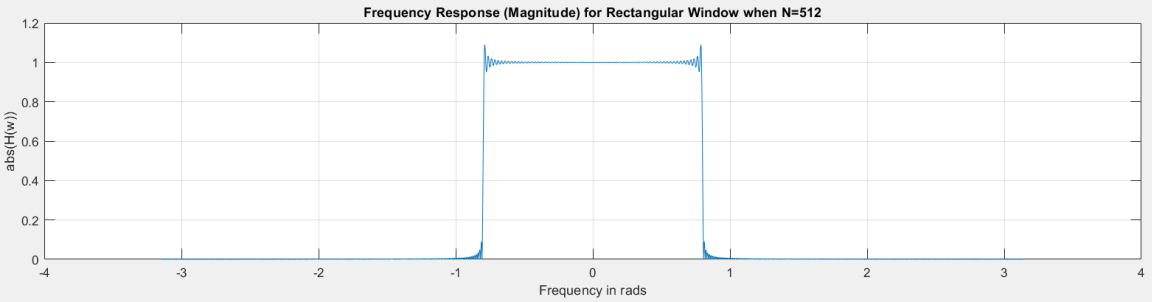
To check how the filters work on noisy signals

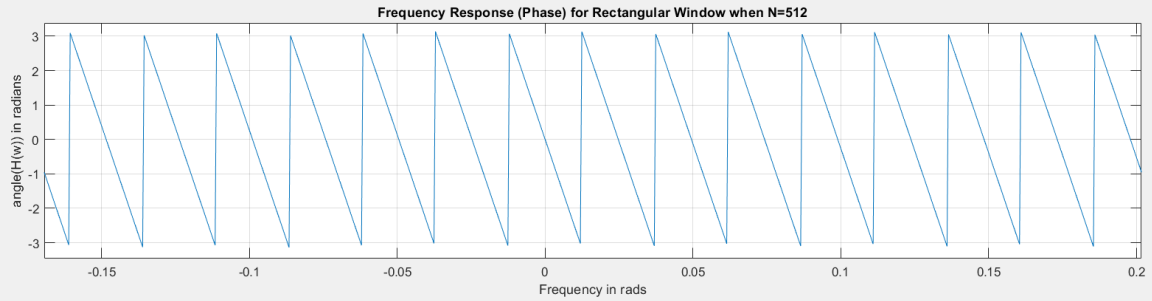
Plots: (Phase plots are zoomed for N=512 in to show the pattern clearly)

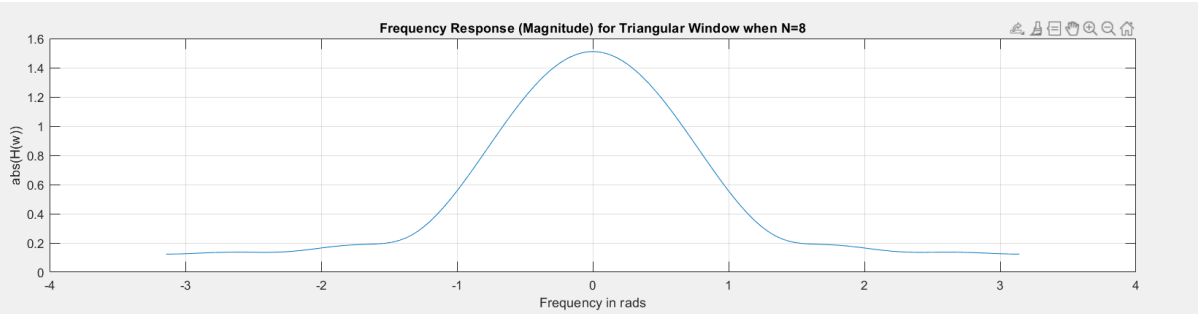
Cut-off angular frequency = 0.8 rads

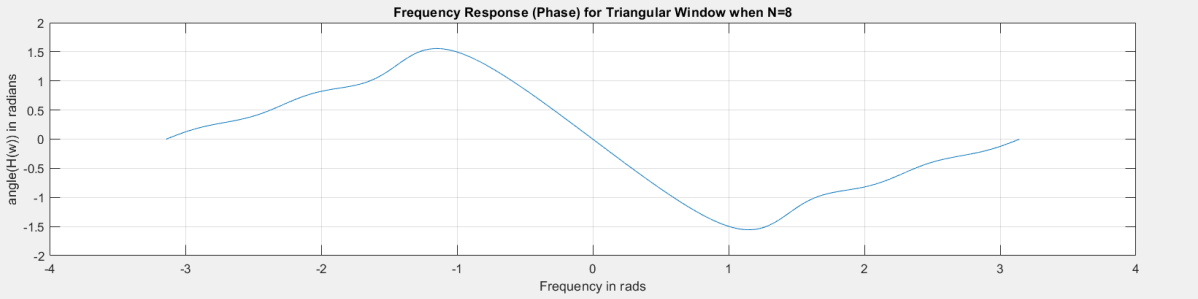

Frequency Response (Magnitude) for Rectangular Window when N=8
abs(H(w))
Frequency in rads

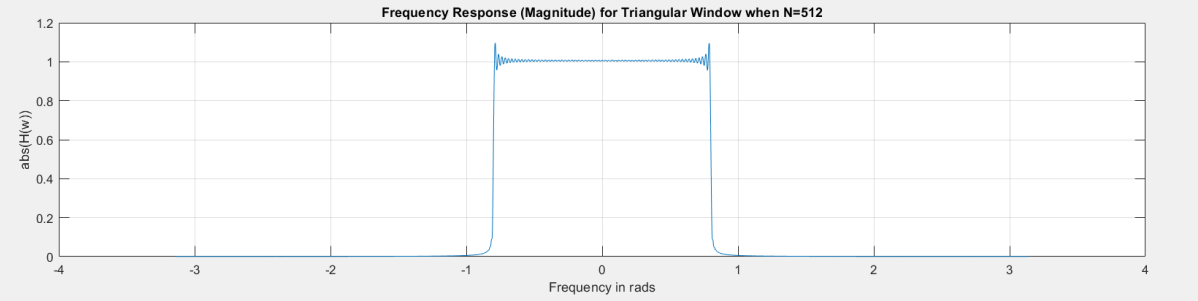

Frequency Response (Phase) for Rectangular Window when N=8
angle(H(w)) in radians
Frequency in rads

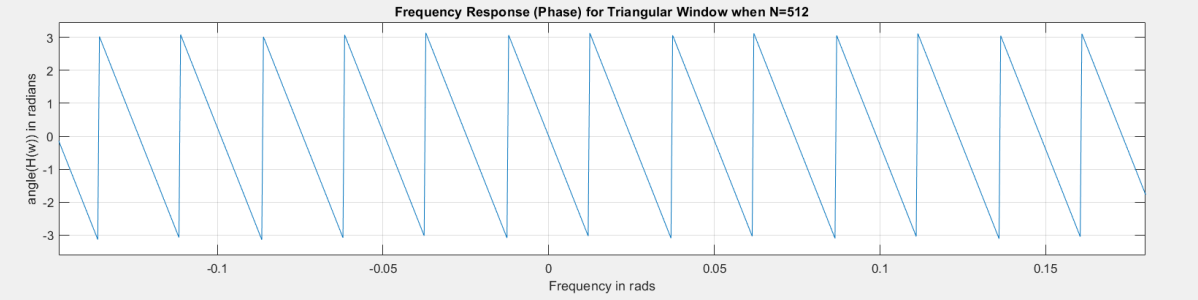

Frequency Response (Magnitude) for Rectangular Window when N=512
abs(H(w))
Frequency in rads


Frequency Response (Phase) for Rectangular Window when N=512
angle(H(w)) in radians
Frequency in rads


Frequency Response (Magnitude) for Triangular Window when N=8
abs(H(w))
Frequency in rads


Frequency Response (Phase) for Triangular Window when N=8
angle(H(w)) in radians
Frequency in rads


Frequency Response (Magnitude) for Triangular Window when N=512
abs(H(w))
Frequency in rads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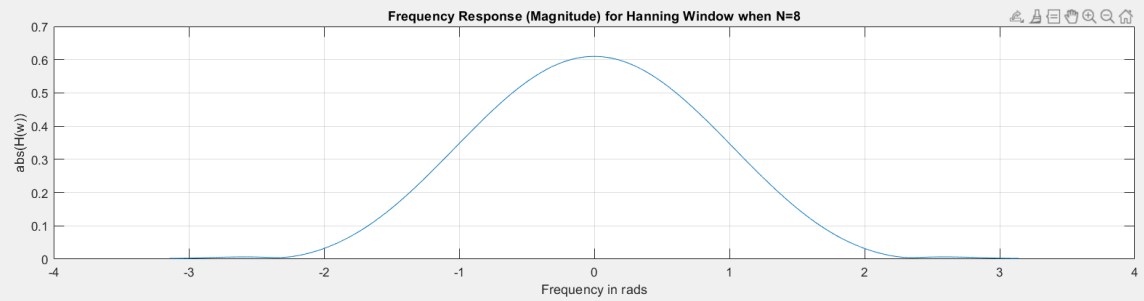
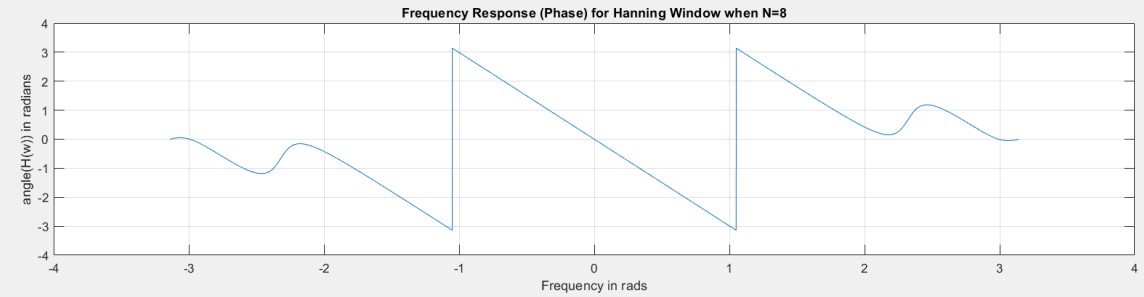
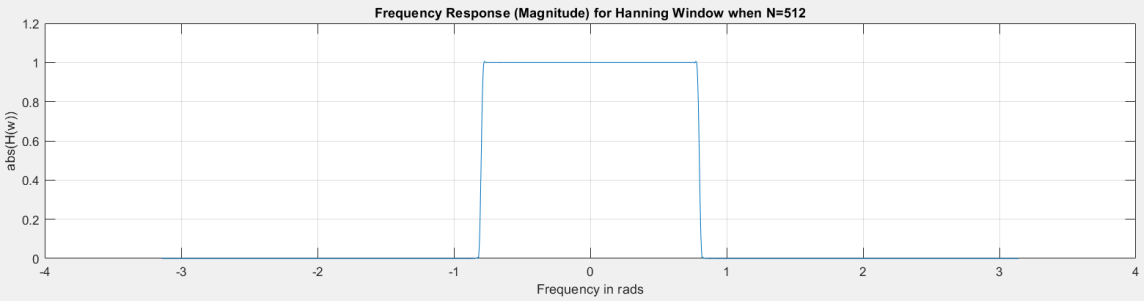
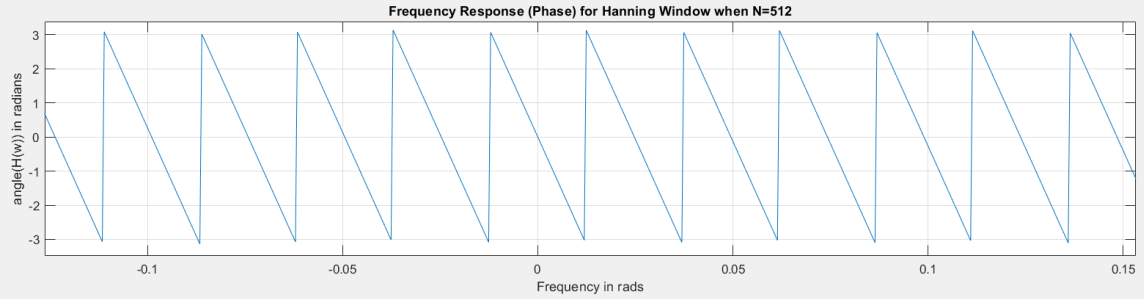
angle(H(w)) in radians
Frequency in rads


Frequency Response (Magnitude) for Hanning Window when N=8
abs(H(w))
Frequency in rads


Frequency Response (Phase) for Hanning Window when N=8
angle(H(w)) in radians
Frequency in rads


Frequency Response (Magnitude) for Hanning Window when N=512
abs(H(w))
Frequency in rads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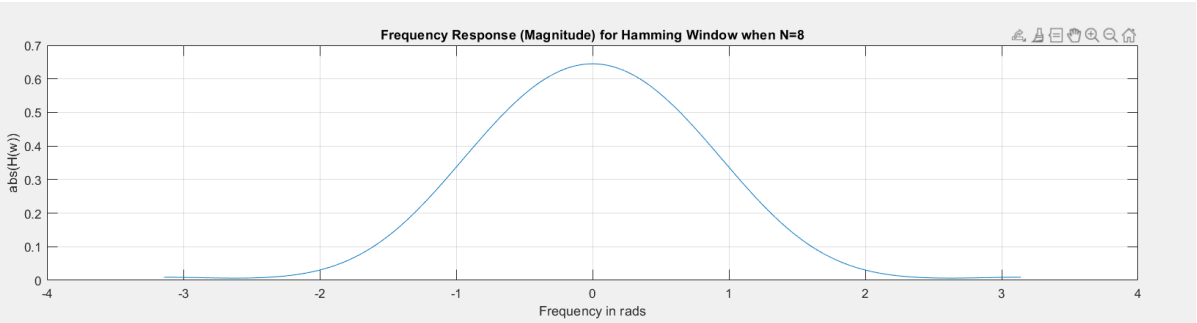
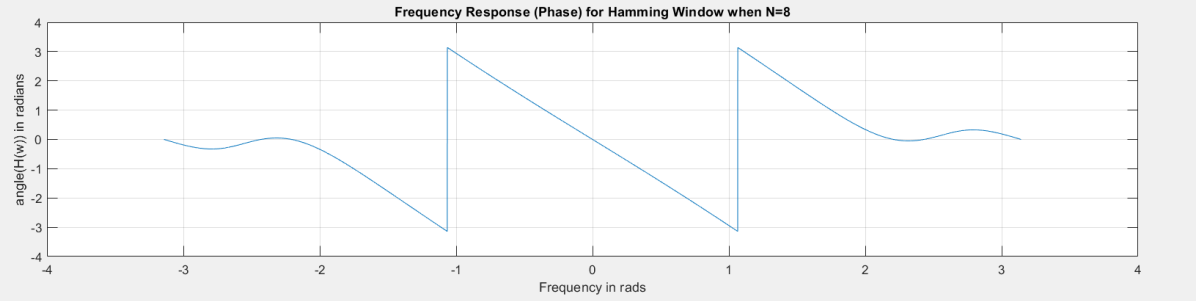
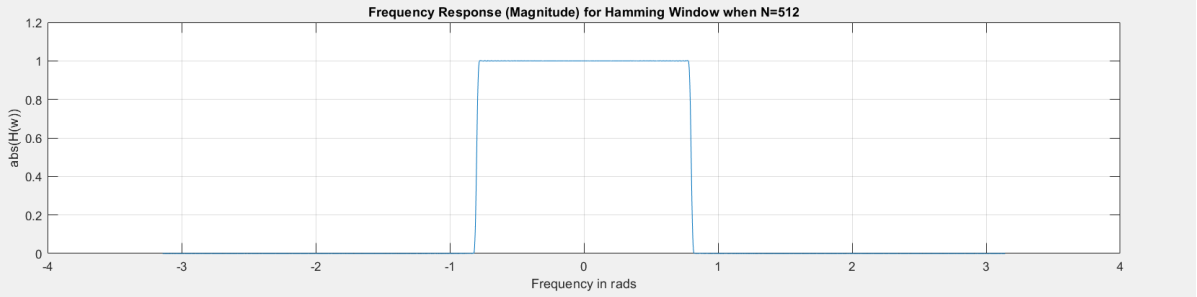
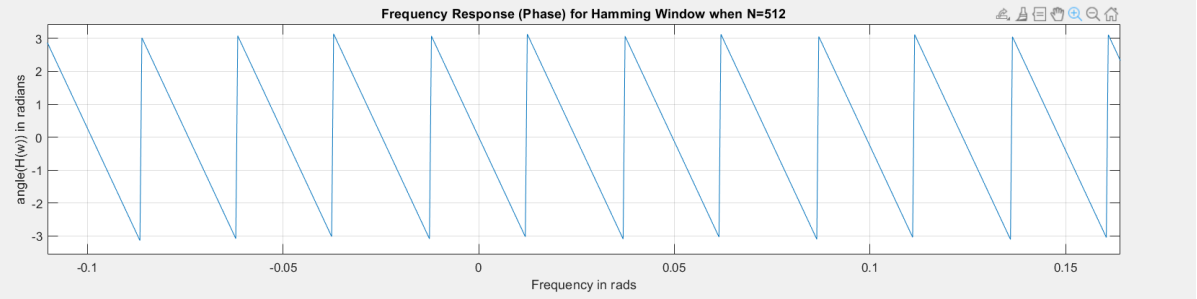
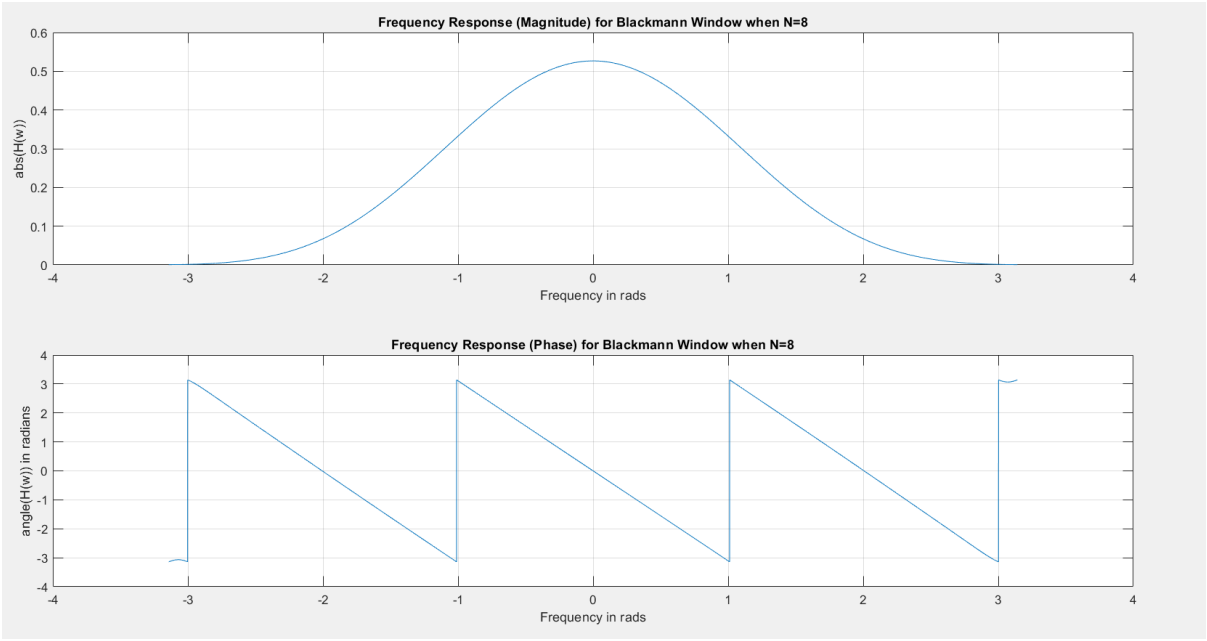
angle(H(w)) in radians
Frequency in rads

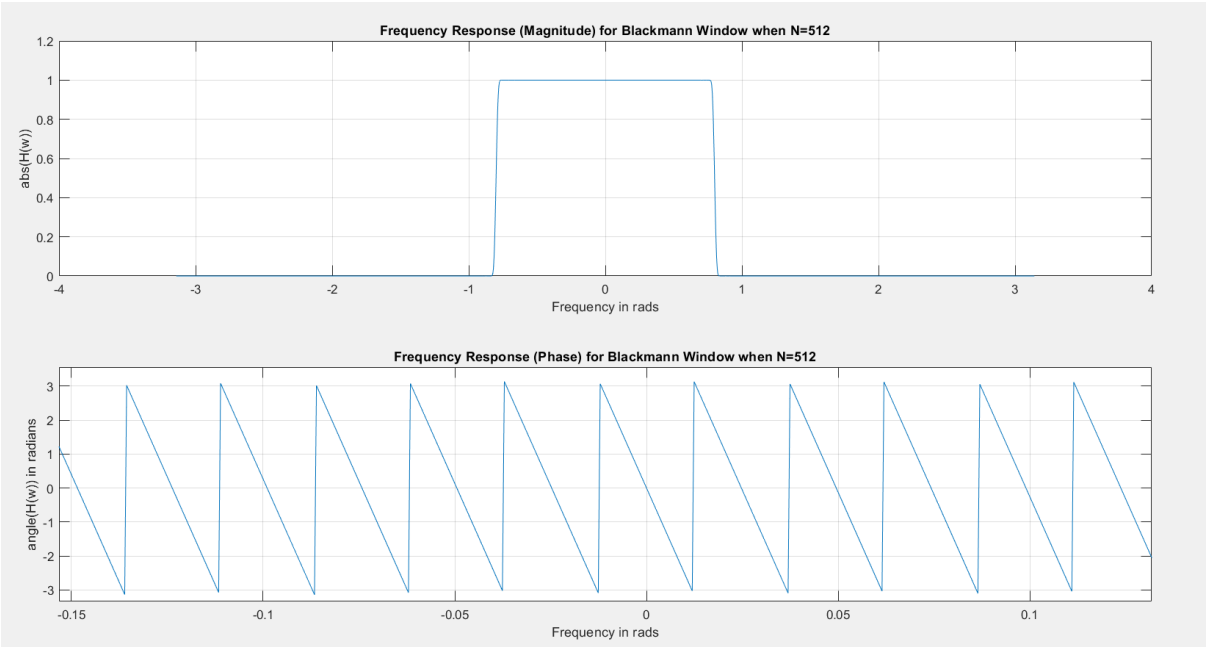

Frequency Response (Magnitude) for Hamming Window when N=8
abs(H(w))
Frequency in rads


Frequency Response (Phase) for Hamming Window when N=8
angle(H(w)) in radians
Frequency in rads


Frequency Response (Magnitude) for Hamming Window when N=512
abs(H(w))
Frequency in rads


Frequency Response (Phase) for Hamming Window when N=512
angle(H(w)) in radians
Frequency in rads


Frequency Response (Magnitude) for Blackmann Window when N=8
abs(H(w))
Frequency in rads
Frequency Response (Phase) for Blackmann Window when N=8
angle(H(w)) in radians
Frequency in rads


Frequency Response (Magnitude) for Blackmann Window when N=512
abs(H(w))
Frequency in rads
Frequency Response (Phase) for Blackmann Window when N=512
angle(H(w)) in radians
Frequency in rads

Code:

```
clc
clear all
close all

N = 8;
k = floor((N-1)/2);
n = 0:1:(N-1);

wc = 0.8;
w = -pi:1/2000:pi;

hd = zeros(1, N);
for ii = 1:N
   if ii == k
      hd(ii) = wc/pi;
   else
      hd(ii) = sin(wc*(ii-k))/(pi*(ii-k));
   end
end

rectangular = ones(1, N);
triangular = 1 - 2*(n-(N-1)/2)/(N-1);
hanning = 0.5 - 0.5*cos((2*pi/(N-1))*n);
hamming = 0.54 - 0.46*cos((2*pi/(N-1))*n);
blackmann = 0.42 - 0.5*cos((2*pi/(N-1))*n) + 0.08*cos((4*pi/(N-1))*n);

h_rect = hd.*rectangular;
h_trig = hd.*triangular;
h_hann = hd.*hanning;
h_hamm = hd.*hamming;
h_black = hd.*blackmann;

[H, W] = freqz(h_rect, 1, w);
figure();
subplot(2,1,1)
plot(W, abs(H));
grid on
xlabel('Frequency in rads');
ylabel('abs(H(w))');
title("Frequency Response (Magnitude) for Rectangular Window when N=" + N);
subplot(2,1,2)
plot(W, angle(H));
grid on
xlabel('Frequency in rads');
ylabel('angle(H(w)) in radians');
title("Frequency Response (Phase) for Rectangular Window when N=" + N);

[H, W] = freqz(h_trig, 1, w);
figure();
subplot(2,1,1)
plot(W, abs(H));
grid on
xlabel('Frequency in rads');
ylabel('abs(H(w))');
title("Frequency Response (Magnitude) for Triangular Window when N=" + N);
```

```
subplot(2,1,2)
plot(W, angle(H));
grid on
xlabel('Frequency in rads');
ylabel('angle(H(w)) in radians');
title("Frequency Response (Phase) for Triangular Window when N=" + N);

[H, W] = freqz(h_hann, 1, w);
figure();
subplot(2,1,1)
plot(W, abs(H));
grid on
xlabel('Frequency in rads');
ylabel('abs(H(w))');
title("Frequency Response (Magnitude) for Hanning Window when N=" + N);
subplot(2,1,2)
plot(W, angle(H));
grid on
xlabel('Frequency in rads');
ylabel('angle(H(w)) in radians');
title("Frequency Response (Phase) for Hanning Window when N=" + N);


[H, W] = freqz(h_hamm, 1, w);
figure();
subplot(2,1,1)
plot(W, abs(H));
grid on
xlabel('Frequency in rads');
ylabel('abs(H(w))');
title("Frequency Response (Magnitude) for Hamming Window when N=" + N);
subplot(2,1,2)
plot(W, angle(H));
grid on
xlabel('Frequency in rads');
ylabel('angle(H(w)) in radians');
title("Frequency Response (Phase) for Hamming Window when N=" + N);

[H, W] = freqz(h_black, 1, w);
figure();
subplot(2,1,1)
plot(W, abs(H));
grid on
xlabel('Frequency in rads');
ylabel('abs(H(w))');
title("Frequency Response (Magnitude) for Blackmann Window when N=" + N);
subplot(2,1,2)
plot(W, angle(H));
grid on
xlabel('Frequency in rads');
ylabel('angle(H(w)) in radians');
title("Frequency Response (Phase) for Blackmann Window when N=" + N);
```