Experiment No:9 Date:15/10/2024

IMPLEMENTATION OF FIR FILTER

Aim

Write a MATLAB program to implement the following FIR filters using Hanning, Hamming, Rectangular and Triangular windows.

a) Low Pass Filter
b) High Pass Filter
c) Band Pass Filter
d) Band Stop Filter

Theory

The FIR (Finite Impulse Response) filter design is a technique used to process signals by allowing certain frequency components to pass while attenuating others. FIR filters have finite-duration impulse responses, meaning they respond only over a limited period after an input is applied. Design of FIR filters relies on defining a desired frequency response and approximating it by truncating the ideal impulse response with a window function, which reduces ripples (sidelobes) and controls the transition width. Common window functions—such as Rectangular, Hamming, Hanning, Blackman, and Kaiser—each offer different trade offs in terms of main-lobe width (defining transition sharpness) and sidelobe attenuation (reducing leakage of undesired frequencies). By choosing appropriate cutoffs and windows, FIR filters can be designed as low-pass, high-pass, band-pass, or band-stop filters, each shaping the frequency content of signals to meet specific application requirements.

Windows:

1. Rectangular window:

$$w_{rec}(n) = 1, \quad -M \leq n \leq M.$$

2. Triangular (Bartlett) window:

$$w_{tri}(n) = 1 - \frac{|n|}{M}, \quad -M \leq n \leq M.$$

3. Hanning window:

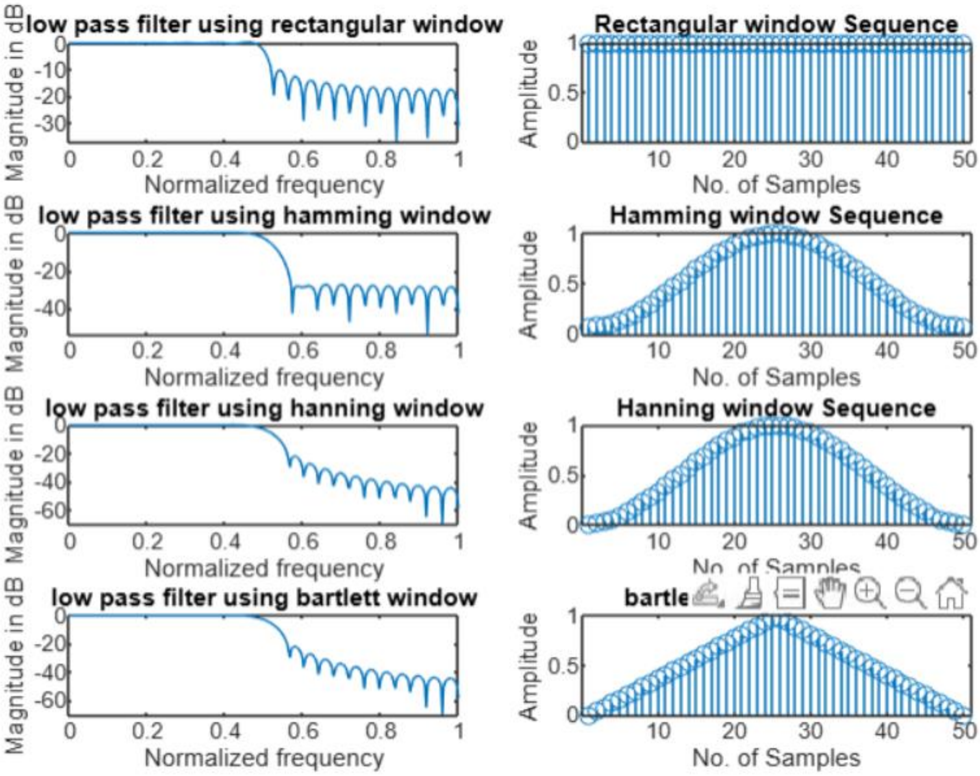
$$w_{han}(n) = 0.5 + 0.5\cos\left(\frac{n\pi}{M}\right), \ -M \leq n \leq M.$$

4. Hamming window:

$$w_{ham}(n) = 0.54 + 0.46\cos\left(\frac{n\pi}{M}\right), \ -M \leq n \leq M.$$

OSERVATION

a)OUTPUT



Filters:

Lowpass: $$h(n) = \begin{cases} \frac{\Omega_c}{\pi} & n = 0 \\ \frac{\sin(\Omega_c n)}{n\pi} \text{ for } n \neq 0 & -M \leq n \leq M \end{cases}$$

Highpass: $$h(n) = \begin{cases} \frac{\pi-\Omega_c}{\pi} & n = 0 \\ -\frac{\sin(\Omega_c n)}{n\pi} \text{ for } n \neq 0 & -M \leq n \leq M \end{cases}$$

Bandpass: $$h(n) = \begin{cases} \frac{\Omega_H-\Omega_L}{\pi} & n = 0 \\ \frac{\sin(\Omega_H n)}{n\pi} - \frac{\sin(\Omega_L n)}{n\pi} \text{ for } n \neq 0 & -M \leq n \leq M \end{cases}$$

Bandstop: $$h(n) = \begin{cases} \frac{\pi-\Omega_H+\Omega_L}{\pi} & n = 0 \\ -\frac{\sin(\Omega_H n)}{n\pi} + \frac{\sin(\Omega_L n)}{n\pi} \text{ for } n \neq 0 & -M \leq n \leq M \end{cases}$$

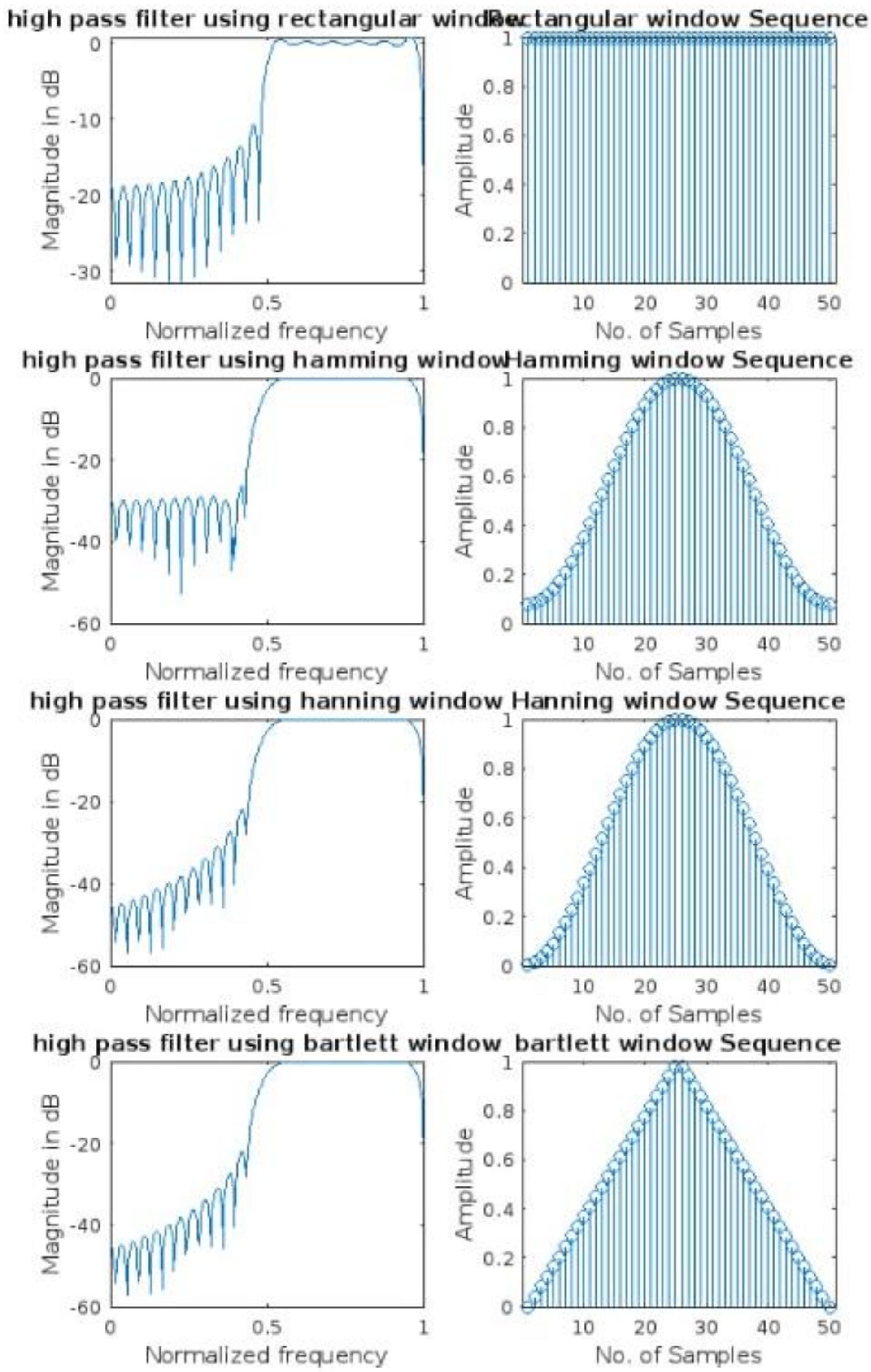
Program

a)Low Pass Filter

```
clc;
clear all;
close all;
wc=0.5*pi;
N=50;

alpha = (N-1)/2;
eps = 0.001;
n = 0:1:N-1;
hd = sin(wc*(n-alpha+eps))./(pi*(n-alpha+eps));

wr = boxcar(N);
wh=hamming(N);
wn=hanning(N);
wt=bartlett(N);
hn = hd.*wr';
hn1=hd.*wh';
```

```
hn2=hd.*wn';
hn3=hd.*wt';
w = 0:0.01:pi;
h = freqz(hn,1,w);
h1 = freqz(hn1,1,w);
h2 = freqz(hn2,1,w);
h3=freqz(hn3,1,w);
subplot(4,2,1);
plot(w/pi,10*log10(abs(h)));
title('low pass filter using rectangular window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,2);
stem(wr);
title('Rectangular window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
subplot(4,2,3);
plot(w/pi,10*log10(abs(h1)));
title('low pass filter using hamming window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,4);
stem(wh);
title('Hamming window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
subplot(4,2,5);
plot(w/pi,10*log10(abs(h2)));
```

b)OUTPUT



high pass filter using rectangular window
Rectangular window Sequence
high pass filter using hamming window
Hamming window Sequence
high pass filter using hanning window
Hanning window Sequence
high pass filter using bartlett window
bartlett window Sequence
Magnitude in dB
Normalized frequency
Amplitude
No. of Samples

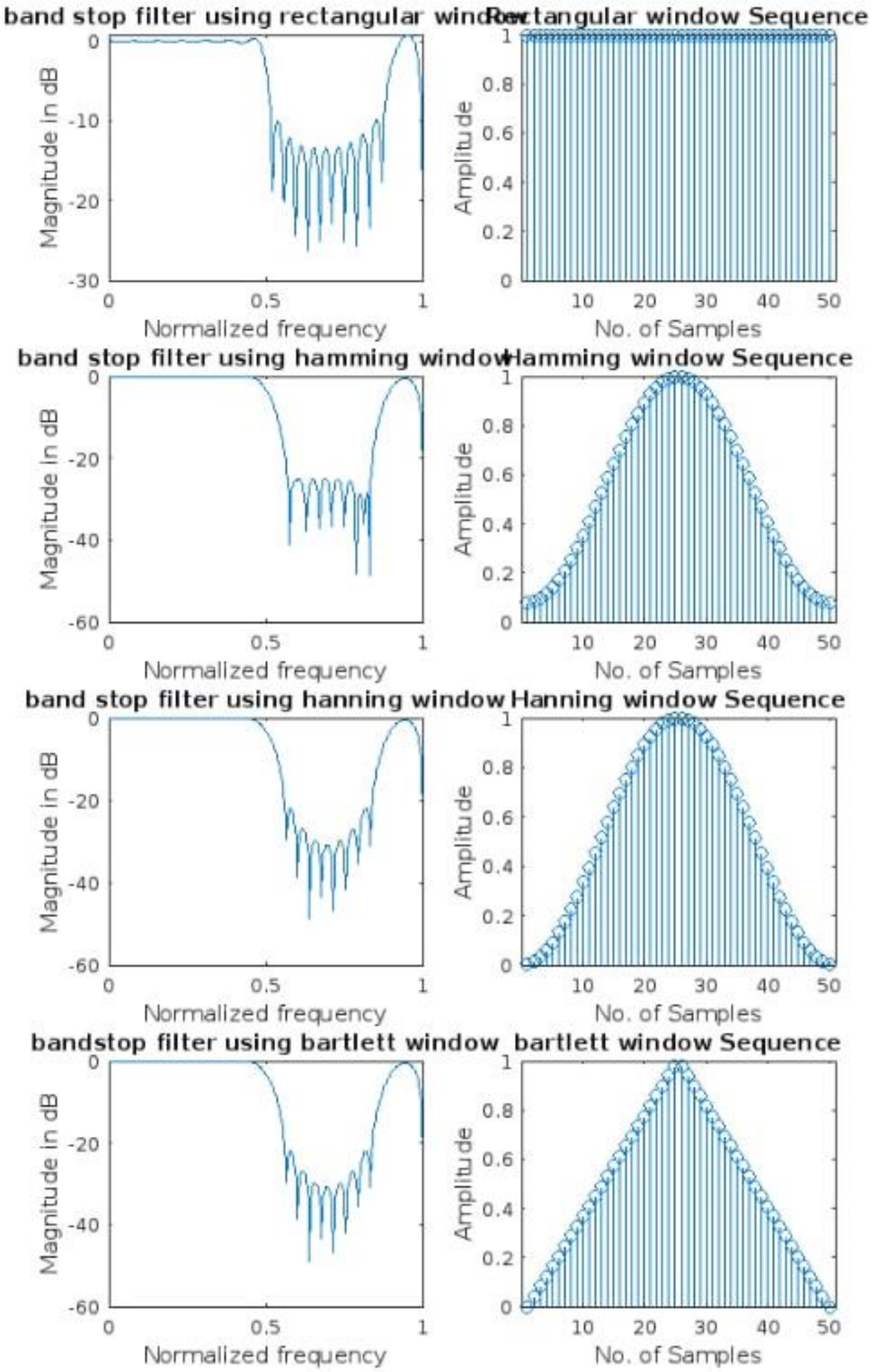
```
title('low pass filter using hanning window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,6);
stem(wn);
title('Hanning window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
subplot(4,2,7);
plot(w/pi,10*log10(abs(h2)));
title('low pass filter using bartlett window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,8);
stem(wt);
title('bartlett window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
```

b)High Pass Filter

```
clc;
clear all;
close all;
wc=0.5*pi;
N=50;
eps=0.001;
N = input('Enter the value of N=');
alpha = (N-1)/2;
```

```
n = 0:1:N-1;
hd = (sin(pi*(n-alpha+eps))-sin(wc*(n-alpha+eps)))./(pi*(n-
alpha+eps));
wr = boxcar(N);
wh=hamming(N);
wn=hanning(N);
wt=bartlett(N);
hn = hd.*wr';
hn1=hd.*wh';
hn2=hd.*wn';
hn3=hd.*wt';
w = 0:0.01:pi;
h = freqz(hn,1,w);
h1 = freqz(hn1,1,w);
h2 = freqz(hn2,1,w);
h3=freqz(hn3,1,w);
subplot(4,2,1);
plot(w/pi,10*log10(abs(h)));
title('high pass filter using rectangular window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,2);
stem(wr);
title('Rectangular window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
subplot(4,2,3);
plot(w/pi,10*log10(abs(h1)));
title('high pass filter using hamming window');
xlabel('Normalized frequency');
```

c)OUTPUT


band stop filter using rectangular window
Rectangular window Sequence
band stop filter using hamming window
Hamming window Sequence
band stop filter using hanning window
Hanning window Sequence
bandstop filter using bartlett window
bartlett window Sequence
Magnitude in dB
Normalized frequency
Amplitude
No. of Samples

```
ylabel('Magnitude in dB');
subplot(4,2,4);
stem(wh);
title('Hamming window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
subplot(4,2,5);
plot(w/pi,10*log10(abs(h2)));
title('high pass filter using hanning window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,6);
stem(wn);
title('Hanning window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
subplot(4,2,7);
plot(w/pi,10*log10(abs(h2)));
title('high pass filter using bartlett window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,8);
stem(wt);
title('bartlett window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
```

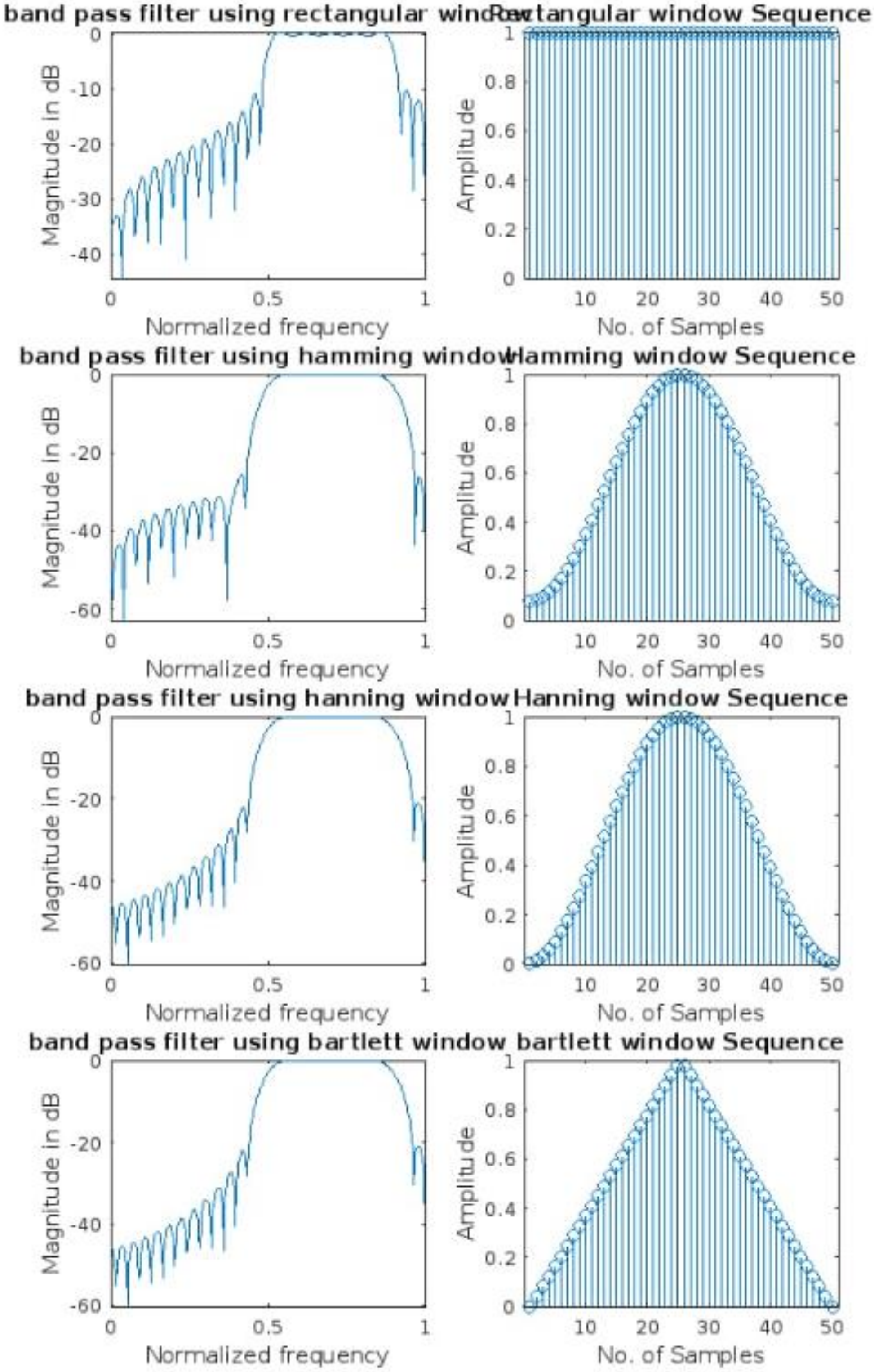
c)Band Stop Filter

```
clc;
clear all;
```

```
close all;

wc1=0.5*pi

w2=0.9*pi;

eps=0.001;

N = 50;

alpha = (N-1)/2;


n = 0:1:N-1;

hd = (sin(wc1*(n-alpha+eps))-sin(wc2*(n-alpha+eps))+sin(pi*(n-
alpha)))./(pi*(n-alpha+eps));

wr = boxcar(N);

wh=hamming(N);

wn=hanning(N);

wt=bartlett(N);

hn = hd.*wr';

hn1=hd.*wh';

hn2=hd.*wn';

hn3=hd.*wt';

w = 0:0.01:pi;

h = freqz(hn,1,w);

h1 = freqz(hn1,1,w);

h2 = freqz(hn2,1,w);

h3=freqz(hn3,1,w);

subplot(4,2,1);

plot(w/pi,10*log10(abs(h)));

title('band stop filter using rectangular window');

xlabel('Normalized frequency');

ylabel('Magnitude in dB');

subplot(4,2,2);

stem(wr);
```

```
title('Rectangular window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
subplot(4,2,3);
plot(w/pi,10*log10(abs(h1)));
title('band stop filter using hamming window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,4);
stem(wh);
title('Hamming window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
subplot(4,2,5);
plot(w/pi,10*log10(abs(h2)));
title('band stop filter using hanning window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,6);
stem(wn);
title('Hanning window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
subplot(4,2,7);
plot(w/pi,10*log10(abs(h2)));
title('bandstop filter using bartlett window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,8);
stem(wt);
```

d)OUTPUT


band pass filter using rectangular window
Rectangular window Sequence
band pass filter using hamming window
Hamming window Sequence
band pass filter using hanning window
Hanning window Sequence
band pass filter using bartlett window
bartlett window Sequence
Magnitude in dB
Amplitude
Normalized frequency
No. of Samples

```
title('bartlett window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
```

d)Band Pass Filter

```
clc;
clear all;
close all;
wc1=0.5*pi;
wc2=0.9*pi;
eps=0.001;
N=50;
alpha = (N-1)/2;

n = 0:1:N-1;
hd = (sin(wc2*(n-alpha+eps))-sin(wc1*(n-alpha+eps)))./(pi*(n-
alpha+eps));
wr = boxcar(N);
wh=hamming(N);
wn=hanning(N);
wt=bartlett(N);
hn = hd.*wr';
hn1=hd.*wh';
hn2=hd.*wn';
hn3=hd.*wt';
w = 0:0.01:pi;
h = freqz(hn,1,w);
h1 = freqz(hn1,1,w);
h2 = freqz(hn2,1,w);
h3=freqz(hn3,1,w);
```

```
subplot(4,2,1);
plot(w/pi,10*log10(abs(h)));
title('band pass filter using rectangular window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,2);
stem(wr);
title('Rectangular window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
subplot(4,2,3);
plot(w/pi,10*log10(abs(h1)));
title('band pass filter using hamming window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,4);
stem(wh);
title('Hamming window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
subplot(4,2,5);
plot(w/pi,10*log10(abs(h2)));
title('band pass filter using hanning window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,6);
stem(wn);
title('Hanning window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
```

```
subplot(4,2,7);
plot(w/pi,10*log10(abs(h2)));
title('band pass filter using bartlett window');
xlabel('Normalized frequency');
ylabel('Magnitude in dB');
subplot(4,2,8);
stem(wt);
title('bartlett window Sequence');
xlabel('No. of Samples');
ylabel('Amplitude');
```

Result

Implemented FIR filters using Window method.