Expt. No. 7. DESIGN OF FIR FILTERS USING WINDOWING TECHNIQUES

Expt. No. 7a. DESIGN OF FIR LOW PASS FILTER USING HANNING WINDOW TECHNIQUE

AIM:

To write a program in MATLAB to plot the magnitude and phase response of FIR low pass filter using Hanning Window technique.

ALGORITHM:

1. Clear the command window.
2. Get the order and cut off frequency of the filter.
3. Compute the desired impulse response $h_d(n)$ of the filter.
4. Obtain different window functions
   - Rectangular window : wh =1
   - Hamming Window : wh = 0.54 – 0.46 cos(2*pi*n/(N-1))
   - Hanning Window : wh = 0.5 – 0.5 cos(2*pi*n/(N-1))
   - Blackman Window : wh = 0.42 – 0.5 cos(2*pi*n/(N-1)) +0.08 cos(4*pi*n/(N-1))
5. Calculate the impulse response of the filter h(n) = h_d(n) * wh for n= -(N-1)/2 to (N+1)/2
6. Compute the frequency response of the filter.
7. Compute the magnitude using abs command.
8. Compute the phase using angle command.
9. Plot the magnitude and phase response.

PROGRAM:

```
%Program to design a FIR filter using windows.
clc
close all
clear all

fprintf('Program for FIR Low Pass filter using windowing technique\n\n');
N =input('Enter the order of the filter: ');
fc=input('Enter the cut off frequency: ');
fs_min = 2 * fc;
fprintf('\nEnter the sampling frequency greater than %d\n',fs_min');
fs_sf=input('Enter the sampling frequency:');
wc=2*pi*fc / fs_sf;
alp = (N-1)/2;
for n = 1 : 1 : N
    if (n - 1) == alp
      hd(n) = wc / pi
    else
      hd(n) = (sin((n-1-alp) * wc))  / (pi*(n-1-alp))
    end
  hannwin(n) = 0.5 - 0.5 * (cos(2*pi*n) / (N-1));
end

hw = hd .* hannwin;

%Computing the frequency response using freqz command

[h omega] = freqz(hw,1,50);

%Finding the magnitude response.
%Plotting magnitude versus omega.
% mag_h = 20 * log10(abs(h));
mag_h = abs(h);
```

```
figure(1);
subplot(2,1,1);
plot(omega/pi,mag_h);

xlabel('frequency normalised to 1 -->');
ylabel('Gain in dB-->');
title('Magnitude Response of LPF');

%Finding the phase response.
%Plotting phase versus omega.
angle_h = angle(h);
subplot(2,1,2);
plot(omega/pi,angle_h)
xlabel('frequency normalised to 1 -->');
ylabel('Phase-->');
title('Phase Response of LPF');
```

OUTPUT:

Enter the order of the filter: 11
Enter the cut off frequency: 1200
Enter the sampling frequency greater than 2400
Enter the sampling frequency:9000

RESULT:

Thus the magnitude and phase response of the FIR low pass filter using Hanning Window technique is plotted using MATLAB.

Expt. No. 7b. DESIGN OF FIR HIGH PASS FILTER USING RECTANGULAR WINDOW TECHNIQUE

AIM:

To write a program in MATLAB to plot the magnitude and phase response of FIR High pass filter using Rectangular Window Technique.

ALGORITHM:

1. Clear the command window.
2. Get the order and cut off frequency of the filter.
3. Compute the desired impulse response $h_d(n)$ of the filter.
4. Obtain different window functions
   - Rectangular window : wh =1
   - Hamming Window : wh = 0.54 – 0.46 cos(2*pi*n/(N-1))
   - Hanning Window : wh = 0.5 – 0.5 cos(2*pi*n/(N-1))
   - Blackman Window : wh = 0.42 – 0.5 cos(2*pi*n/(N-1)) +0.08 cos(4*pi*n/(N-1))
5. Calculate the impulse response of the filter h(n) = $h_d(n)$ * wh for n= -(N-1)/2 to (N+1)/2
6. Compute the frequency response of the filter.
7. Compute the magnitude using abs command.
8. Compute the phase using angle command.
9. Plot the magnitude and phase response.

PROGRAM:

```
%Program to design a FIR filter using windows.
clc
close all
clear all

fprintf('Program for FIR High pass filter using windowing technique\n\n');
N =input('Enter the order of the filter: ');
fc=input('Enter the cut off frequency: ');
fs_min = 2 * fc;
fprintf('\nEnter the sampling frequency greater than %d\n',fs_min');
fs_sf=input('Enter the sampling frequency:');
wc=2*pi*fc / fs_sf;
alp = (N-1)/2;
for n = 1 : 1 : N
     if (n - 1) == alp
       hd(n) = (pi - wc) / pi
     else
        hd(n)=(sin((n-1-alp)*pi))-(sin(n-1-alp)*wc)/(pi*(n-1-alp))
     end
   rect_win(n)=1
end

hw=hd .* rect_win;

%Computing the frequency response using freqz command

[h omega] = freqz(hw,1,50);


%Finding the magnitude response.
%Plotting magnitude versus omega.
% mag_h = 20 * log10(abs(h));
```

```
mag_h = abs(h);

figure(1);
subplot(2,1,1);
plot(omega/pi,mag_h);

xlabel('frequency normalised to 1 -->');
ylabel('Gain in dB-->');
title('Magnitude Response of HPF');

%Finding the phase response.
%Plotting phase versus omega.
angle_h = angle(h);
subplot(2,1,2);
plot(omega/pi,angle_h)
xlabel('frequency normalised to 1 -->');
ylabel('Phase-->');
title('Phase Response of HPF');
```

OUTPUT:

Enter the order of the filter: 11
Enter the cut off frequency: 1200
Enter the sampling frequency greater than 2400
Enter the sampling frequency:9000

RESULT:

Thus the magnitude and phase response of the FIR High pass filter using Rectangular Window technique is plotted using MATLAB.

Expt. No. 7c. DESIGN OF FIR BAND PASS FILTER USING HAMMING WINDOW TECHNIQUE

AIM:

To write a program in MATLAB to plot the magnitude and phase response of FIR band pass filter using Hamming Window technique.

ALGORITHM:

1. Clear the command window.
2. Get the order and cut off frequency of the filter.
3. Compute the desired impulse response $h_d(n)$ of the filter.
4. Obtain different window functions
   - Rectangular window : wh =1
   - Hamming Window : wh = 0.54 – 0.46 cos(2*pi*n/(N-1))
   - Hanning Window : wh = 0.5 – 0.5 cos(2*pi*n/(N-1))
   - Blackman Window : wh = 0.42 – 0.5 cos(2*pi*n/(N-1)) +0.08 cos(4*pi*n/(N-1))
5. Calculate the impulse response of the filter h(n) = h_d(n) * wh for n= -(N-1)/2 to (N+1)/2
6. Compute the frequency response of the filter.
7. Compute the magnitude using abs command.
8. Compute the phase using angle command.
9. Plot the magnitude and phase response.

PROGRAM:

```
%Program to design a FIR filter using windows.
clc;
clear all;
close all;
N =input('Enter the order of the filter: ');
fs1=input('Enter the stop edge frequency1:');
fc1=input('Enter the pass edge frequency1:');
fc2=input('Enter the pass edge frequency2:');
fs2=input('Enter the stop edge frequency2:');

%fs_min should be twice the maximum frequency. Here, fs_min = 2*fs2.
fs_min = 2*fs2;
fprintf('\nEnter the sampling frequency greater than %d\n',fs_min');
fs_sf=input('Enter the sampling frequency:');

%We get the attenuation in dB. rp will be around 0 to 3 dB
%rs will be around 30 to 50 dB
rp = input('\nEnter the passband ripple in dB:');
rs = input('Enter the stopband attenuation in dB:');

ws1=2*pi*fs1/fs_sf;
wc1=2*pi*fc1/fs_sf;
wc2=2*pi*fc2/fs_sf;
ws2=2*pi*fs2/fs_sf;

alp = (N-1)/2;
for n = 1 : 1 : N
    if (n - 1) == alp
      hd(n) = (wc2-wc1) / pi
    else
      hd(n)=(sin((n-1-alp)*wc2))-(sin(n-1-alp)*wc1)/(pi*(n-1-alp))
    end
  hammwin(n) = 0.54 - 0.46 * (cos(2*pi*n) / (N-1));
```

```
end

hw = hd .* hammwin;

%Computing the frequency response using freqz command

[h omega] = freqz(hw,1,50);


%Finding the magnitude response.
%Plotting magnitude versus omega.
% mag_h = 20 * log10(abs(h));
mag_h = abs(h);

figure(1);
subplot(2,1,1);
plot(omega/pi,mag_h);

xlabel('frequency normalised to 1 -->');
ylabel('Gain in dB-->');
title('Magnitude Response of BPF');

%Finding the phase response.
%Plotting phase versus omega.
angle_h = angle(h);
subplot(2,1,2);
plot(omega/pi,angle_h)
xlabel('frequency normalised to 1 -->');
ylabel('Phase-->');
title('Phase Response of BPF');
```

OUTPUT:

```
Enter the order of the filter: 11
Enter the stop edge frequency1:1000
Enter the pass edge frequency1:3000
Enter the pass edge frequency2:6000
Enter the stop edge frequency2:9000
Enter the sampling frequency greater than 18000
Enter the sampling frequency:20000
Enter the passband ripple in dB:.3
Enter the stopband attenuation in dB:60
```

RESULT:

Thus the magnitude and phase response of the FIR Band Pass filter using Hamming Window technique is plotted using MATLAB.

Expt. No. 7d. DESIGN OF FIR BAND STOP FILTER USING BLACKMAN WINDOW TECHNIQUE

AIM:

To write a program in MATLAB to plot the magnitude and phase response of FIR Band Stop filter using Blackman Window Technique.

ALGORITHM:

1. Clear the command window.
2. Get the order and cut off frequency of the filter.
3. Compute the desired impulse response $h_d(n)$ of the filter.
4. Obtain different window functions
   - Rectangular window : wh =1
   - Hamming Window : wh = 0.54 – 0.46 cos(2*pi*n/(N-1))
   - Hanning Window : wh = 0.5 – 0.5 cos(2*pi*n/(N-1))
   - Blackman Window : wh = 0.42 – 0.5 cos(2*pi*n/(N-1)) +0.08 cos(4*pi*n/(N-1))
5. Calculate the impulse response of the filter h(n) = h_d(n) * wh for n= -(N-1)/2 to (N+1)/2
6. Compute the frequency response of the filter.
7. Compute the magnitude using abs command.
8. Compute the phase using angle command.
9. Plot the magnitude and phase response.

PROGRAM:

```
%Program to design a FIR filter using windows.
clc;
clear all;
close all;
N =input('Enter the order of the filter: ');
fp1=input('Enter the pass edge frequency1:');
fc1=input('Enter the stop edge frequency1:');
fc2=input('Enter the stop edge frequency2:');
fp2=input('Enter the pass edge frequency2:');


%fs_min should be twice the maximum frequency. Here, fs_min = 2*fs2.
fs_min = 2*fp2;
fprintf('\nEnter the sampling frequency greater than %d\n',fs_min');
fs_sf=input('Enter the sampling frequency:');

%We get the attenuation in dB. rp will be around 0 to 3 dB
%rs will be around 30 to 50 dB
rp = input('\nEnter the passband ripple in dB:');
rs = input('Enter the stopband attenuation in dB:');

wp1=2*pi*fp1/fs_sf;
wc1=2*pi*fc1/fs_sf;
wc2=2*pi*fc2/fs_sf;
wp2=2*pi*fp2/fs_sf;

alp = (N-1)/2;

for n = 1 : 1 : N
    if (n - 1) == alp
      hd(n) =1 - ((wc2-wc1 )/ pi)
    else
     hd(n)=((sin((n-1-alp)*wc1))-(sin(n-1-alp)*wc2)+ sin((n-1-alp)*pi))/(pi*(n-1-alp))
% hd(n)=((sin((n-1-alp)*wc1))-(sin(n-1-alp)*wc2)/(pi*(n-1-alp)))
```

```
    end
  blackwin(n) = 0.42 - 0.5 * (cos(2*pi*n) / (N-1)) + 0.08 * (cos(4*pi*n)  / (N-1));

end

hw = hd .* blackwin;

%Computing the frequency response using freqz command

[h omega] = freqz(hw,1,50);


%Finding the magnitude response.
%Plotting magnitude versus omega.
% mag_h = 20 * log10(abs(h));
mag_h = abs(h);

figure(1);
subplot(2,1,1);
plot(omega/pi,mag_h);

xlabel('frequency normalised to 1 -->');
ylabel('Gain in dB-->');
title('Magnitude Response of BRF');

%Finding the phase response.
%Plotting phase versus omega.
angle_h = angle(h);
subplot(2,1,2);
plot(omega/pi,angle_h)
xlabel('frequency normalised to 1 -->');
ylabel('Phase-->');
title('Phase Response of BRF');
```

OUTPUT:

```
Enter the order of the filter: 11
Enter the pass edge frequency1: 1000
Enter the stop edge frequency1: 3000
Enter the stop edge frequency2:6000
Enter the pass edge frequency2:9000
Enter the sampling frequency greater than 18000
Enter the sampling frequency:20000
Enter the passband ripple in dB:.3
Enter the stopband attenuation in dB:60
```

RESULT:

Thus the magnitude and phase response of the FIR Band Stop filter using Blackman Window technique is plotted using MATLAB.

Expt. No. 8. DESIGN OF FIR FILTERS USING FOURIER SERIES METHOD

Expt. No. 8a. DESIGN OF FIR LOW PASS FILTER USING FOURIER SERIES METHOD

AIM:

To write a program in MATLAB to plot the magnitude and phase response of FIR low pass filter using Fourier Series method.

ALGORITHM:

10. Clear the command window.
11. Get the order and cut off frequency of the filter.
12. Compute the desired impulse response $h_d(n)$ of the filter.
13. Calculate the impulse response of the filter $h_n(n) = h_d(n)$ for n= -(N-1)/2 to (N+1)/2
14. Compute the magnitude using abs command.
15. Compute the phase using angle command.
16. Plot the magnitude and phase response.

PROGRAM:

```
%Program to plot frequency response of FIR LPF
clc
clear all
close all
wc=.5*pi;
N=11;
hd=zeros(1,N);
hd(1)=wc/pi;
n = 1:1:((N-1)/2)+1;
hd(n+1) = (sin(wc*n)) . / (pi*n);
hn(n) = hd(n)
a=(N-1)/2;
w=0: pi/16:pi;
Hw1=hn(1)*exp(-j*w*a);
Hw2=0;

for m = 1:1:a;
   Hw3 = hn(m+1) * ((exp(j*w*(m-a))) + exp(-j*w*(m+a)));
   Hw2 = Hw2 + Hw3;
end
Hw = Hw2 + Hw1

%Finding the magnitude response. Note: log10 should be used.
%Plotting magnitude versus omega.

mag_h=abs(Hw)
subplot(2,1,1);
plot(w/pi,mag_h);
xlabel('Normalised Frequency,w/pi -->');
ylabel('Magnitude -->');
title('Magnitude Response of LPF');

%Finding the phase response.
%Plotting phase versus omega.
angle_h=angle(Hw);
subplot(2,1,2);
plot(w/pi,angle_h);
xlabel('Normalised Frequency,w/pi -->');
ylabel('Phase -->');
```

```
title('Phase Response of LPF');
```

RESULT:

Thus the magnitude and phase response of the FIR low pass filter using Fourier Series method is plotted using MATLAB.

Expt. No. 8b. DESIGN OF FIR HIGH PASS FILTER USING FOURIER SERIES METHOD

AIM:

To write a program in MATLAB to plot the magnitude and phase response of FIR high pass filter using Fourier Series method.

ALGORITHM:

1. Clear the command window.
2. Get the order and cut off frequency of the filter.
3. Compute the desired impulse response $h_d(n)$ of the filter.
4. Calculate the impulse response of the filter $h_n(n) = h_d(n)$ for n= -(N-1)/2 to (N+1)/2
5. Compute the magnitude using abs command.
6. Compute the phase using angle command.
7. Plot the magnitude and phase response.

PROGRAM:

```
%Program to plot frequency response of FIR HPF
clc
clear all
close all
wc=.6*pi;
N=7;
hd=zeros(1,N);
hd(1)=1-(wc/pi);
n = 1:1:((N-1)/2)+1;
hd(n+1) = (-sin(wc*n)) . / (pi*n);
hn(n) = hd(n)
a=(N-1)/2;
w=0: (pi/16):pi;
Hw1=hn(1)*exp(-j*w*a);
Hw2=0;

for m = 1:1:a;
   Hw3 = hn(m+1) * ((exp(j*w*(m-a))) + exp(-j*w*(m+a)));
   Hw2 = Hw2 + Hw3;
end
Hw = Hw2 + Hw1

%Finding the magnitude response. Note: log10 should be used.
%Plotting magnitude versus omega.

mag_h=abs(Hw)
subplot(2,1,1);
plot(w/pi,mag_h);
xlabel('Normalised Frequency,w/pi -->');
ylabel('Magnitude -->');
title('Magnitude Response of HPF');

%Finding the phase response.
%Plotting phase versus omega.
angle_h=angle(Hw);
subplot(2,1,2);
plot(w/pi,angle_h);
xlabel('Normalised Frequency,w/pi -->');
ylabel('Phase -->');
title('Phase Response of HPF');
```

RESULT:

Thus the magnitude and phase response of the FIR high pass filter using Fourier Series method is plotted using MATLAB.

Expt. No. 8c. DESIGN OF FIR BAND PASS FILTER USING FOURIER SERIES METHOD

AIM:

To write a program in MATLAB to plot the magnitude and phase response of FIR band pass filter using Fourier Series method.

ALGORITHM:

1. Clear the command window.
2. Get the order and cut off frequency of the filter.
3. Compute the desired impulse response $h_d(n)$ of the filter.
4. Calculate the impulse response of the filter $h_n(n) = h_d(n)$ for n= -(N-1)/2 to (N+1)/2
5. Compute the magnitude using abs command.
6. Compute the phase using angle command.
7. Plot the magnitude and phase response.

PROGRAM:

```
%Program to plot frequency response of FIR BPF
clc
clear all
close all
wc1=.375*pi;
wc2=.75*pi;
N=7;
hd=zeros(1,N);

hd(1)=(wc2-wc1)/pi;
n = 1:1:((N-1)/2)+1;
hd(n+1) = ((sin(wc2*n))-(sin(wc1*n))) . / (pi*n);
hn(n) = hd(n)
a=(N-1)/2;
w=0: (pi/16):pi;
Hw1=hn(1)*exp(-j*w*a);
Hw2=0;

for m = 1:1:a;
   Hw3 = hn(m+1) * ((exp(j*w*(m-a))) + exp(-j*w*(m+a)));
   Hw2 = Hw2 + Hw3;
end
Hw = Hw2 + Hw1

%Finding the magnitude response. Note: log10 should be used.
%Plotting magnitude versus omega.

mag_h=abs(Hw)
subplot(2,1,1);
plot(w/pi,mag_h);
xlabel('Normalised Frequency,w/pi -->');
ylabel('Magnitude -->');
title('Magnitude Response of BPF');

%Finding the phase response.
%Plotting phase versus omega.
angle_h=angle(Hw);
subplot(2,1,2);
plot(w/pi,angle_h);
xlabel('Normalised Frequency,w/pi -->');
```

```
ylabel('Phase -->');
title('Phase Response of BPF');
```

RESULT:

Thus the magnitude and phase response of the FIR band pass filter using Fourier Series method is plotted using MATLAB.

Expt. No. 8d. DESIGN OF FIR BAND STOP FILTER USING FOURIER SERIES METHOD

AIM:

To write a program in MATLAB to plot the magnitude and phase response of FIR band stop filter using Fourier Series method.

ALGORITHM:

1. Clear the command window.
2. Get the order and cut off frequency of the filter.
3. Compute the desired impulse response $h_d(n)$ of the filter.
4. Calculate the impulse response of the filter $h_n(n) = h_d(n)$ for n= -(N-1)/2 to (N+1)/2
5. Compute the magnitude using abs command.
6. Compute the phase using angle command.
7. Plot the magnitude and phase response.

PROGRAM:

```
%Program to plot frequency response of FIR BRF
clc
clear all
close all
wc1=.375*pi;
wc2=.75*pi;
N=7;
hd=zeros(1,N);

hd(1)=1-((wc2-wc1)/pi);
n = 1:1:((N-1)/2)+1;
hd(n+1) = (((sin(wc1*n))-(sin(wc2*n))) . / (pi*n));
hn(n) = hd(n)
a=(N-1)/2;
w=0: (pi/16):pi;
Hw1=hn(1)*exp(-j*w*a);
Hw2=0;

for m = 1:1:a;
   Hw3 = hn(m+1) * ((exp(j*w*(m-a))) + exp(-j*w*(m+a)));
   Hw2 = Hw2 + Hw3;
end
Hw = Hw2 + Hw1

%Finding the magnitude response. Note: log10 should be used.
%Plotting magnitude versus omega.

mag_h=abs(Hw)
subplot(2,1,1);
plot(w/pi,mag_h);
xlabel('Normalised Frequency,w/pi -->');
ylabel('Magnitude -->');
title('Magnitude Response of BRF');

%Finding the phase response.
%Plotting phase versus omega.
angle_h=angle(Hw);
subplot(2,1,2);
plot(w/pi,angle_h);
```

```
xlabel('Normalised Frequency,w/pi -->');
ylabel('Phase -->');
title('Phase Response of BRF');
```

RESULT:

Thus the magnitude and phase response of the FIR band stop filter using Fourier Series method is plotted using MATLAB.