

**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.