

Experiment-5.IIR FILTERS

% Butterworth low pass filter with $\omega_p = 5\text{dB}$, $\omega_s = 15\text{dB}$, $\Omega_p = 1000\text{Hz}$, $\Omega_s = 1500\text{Hz}$
 $F = 10\text{kHz}$.

```
clc;
clear all;
close all;

rp = input('enter the pass band in dB: ');
rs = input('enter the stop band in dB: ');
fp = input('enter passband cutoff frequency in hz: ');
fs = input('enter stopband cutoff frequency in hz: ');
f = input('enter the sampling frequency: ');

wp = 2*fp/f;
ws = 2*fs/f;

[N,wc] = buttord(wp,ws,rp,rs);
disp('order of the filter = '); N
disp('cutoff frequency'); wc

[b,a] = butter(N,wc,'low');
disp('a'); a
disp('b'); b

[H,om] = freqz(b,a);
subplot(1,3,1);
plot(om/pi,abs(H));
title('magnitude plot');
subplot(1,3,2);
plot(om/pi,angle(H));
```

```

title ('phase plot');
subplot (1,3,3);
plot (omlp, 20*log10(cars(h)))';
title ('magnitude plot in dB');

```

Result:

enter the pass band in dB: 5
 enter the stop band in dB: 15
 enter stopband cutoff frequency in Hz: 1500
 enter passband cut-off frequency in Hz: 1000
 enter the sampling frequency: 10000
 order of the filter =

$$N = 3$$

Cutoff frequency

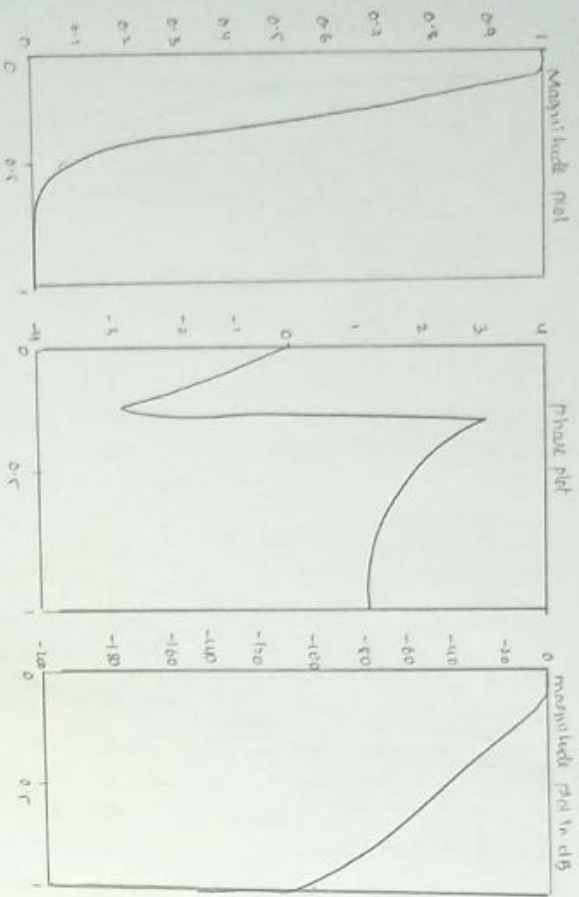
$$WC = 0.1486$$

$$Q =$$

$$1.0000 \quad -1.8904 \quad 1.3191 \quad -0.3205$$

$$b =$$

$$0.0135 \quad 0.0406 \quad 0.0406 \quad 0.0135$$



✓ Butterworth high pass.

clc;

clear all;

close all;

rs = input('enter the stop band in dB: ');

rp = input('enter the pass band in dB: ');

fs = input('enter the stop band cutoff frequency in Hz: ');

fp = input('enter the pass band cutoff frequency in Hz: ');

fz = input('enter the sampling frequency: ');

ws = 2 * fs / fz;

wpf = 2 * fp / fz;

[N,wc] = buttord(ws,wp,rs,rp);

disp('order of the filter = '); N

disp('cutoff frequency'); wc

[b,a] = butter(N,wc,'high');

[H,f] = freqz(b,a);

disp('a'); a

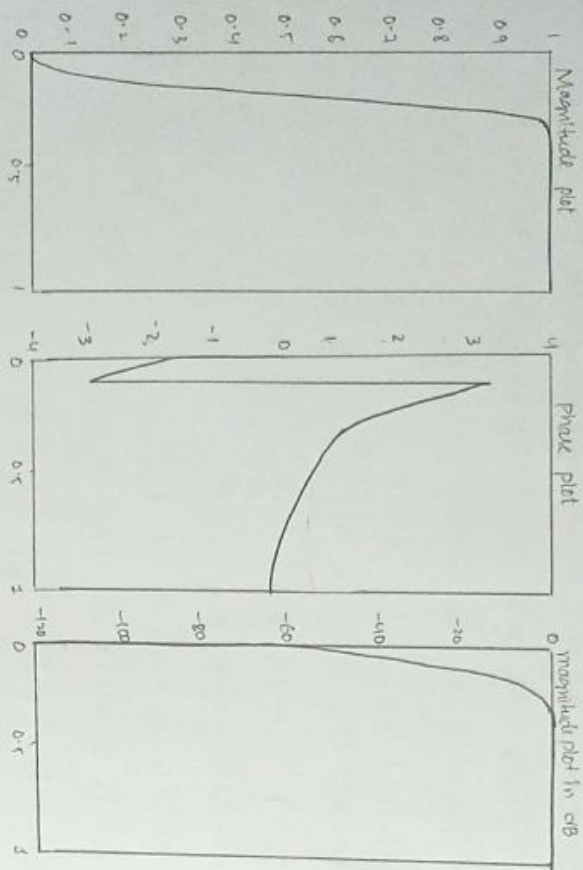
disp('b'); b

[H,om] = freqz(b,a);

subplot(1,3,1);

plot(om/pi,abs(H));

title('magnitude plot');



```

subplot(1,3,2);
plot(compl, angle(h));
title('phase plot');
subplot(1,3,3);
plot(*ompl, 20*log10(abs(h)));
title('magnitude plot in dB');

```

Result:

enter the stop band in dB: 5
 enter the pass band in dB: 15
 enter the stopband cutoff frequency in hz: 1000
 enter the passband cutoff frequency in hz: 1500
 enter the sampling frequency: 10,000

Order of the filter =

N = 3.

cutoff frequency

WC = 0.1786

Q =

1.0000 -1.8904 1.3191 -0.3205

b =

0.5663 -1.6988 1.6988 -0.5663.

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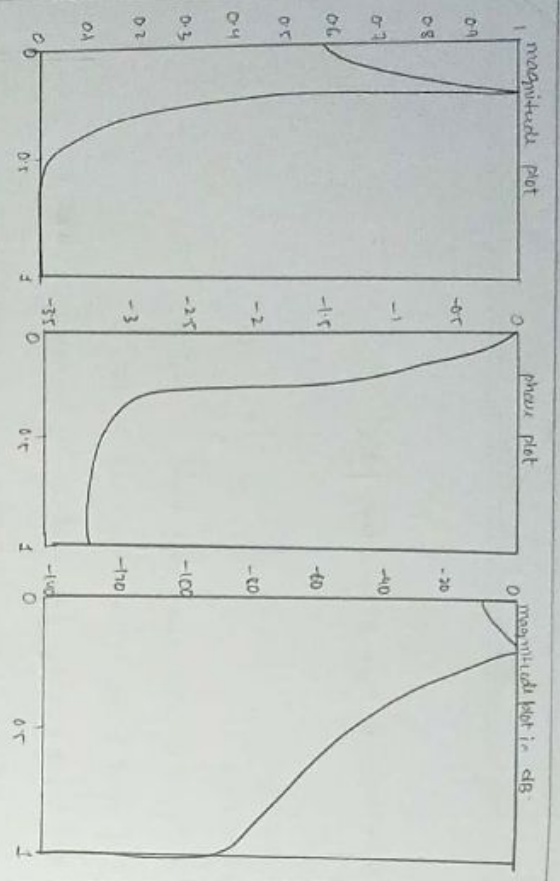
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7. Chebyshev type-1 low pass filter

```
clc;
clearall;
closeall;

wp=input('enter the pass band in dB:');
ws=input('enter the stop band in dB:');
fp=input('enter pass band cutoff frequency in Hz');
fs=input('enter stop band cutoff frequency in Hz');
fs=input('enter the sampling frequency');

wpr=2*pi*fp/t;
wsr=2*pi*fs/t;
[N,wc]=cheb1ord(wpr,wsr,wp,ws);
disp('order of the filter=');N
disp('cutoff frequency');wc
[b,a]=cheb1z(N,wp,wc);
disp('a');a
disp('b');b
[h,om]=freqz(b,a);
subplot(1,3,1);
plot(om/pi,abs(h));
title('magnitude plot');
```



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```
subplot(1,3,2);
plot(comlp1,angle(h));
title('phase plot');
subplot(1,3,3);
plot(comlp1,20*log10(abs(h)));
title('magnitude plot in dB');
```

Result

enter the pass band in dB: 5
enter the stop band attenuation in dB: 15
enter passband cutoff frequency: 1000
enter stop band cutoff frequency: 1500
enter the sampling frequency: 10000
order of the filter =

N=2-

cutoff frequency

wc = 0.2000

a =

1.0000 -1.5442 0.7548

b =

0.0096 0.0592 0.0290

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% chebyshev type-1 high pass filter

clc;

clear all;

close all;

rs = input('enter the stopband in dB:');
 rp = input('enter the passband in dB:');

fs = input('enter the stopband cutoff frequency:');

fp = input('enter the passband cutoff frequency:');

fz = input('enter the sampling frequency:');

ws = 2*pi*fs/f;

wP = 2*pi*fp/f;

[N,wc], cheb1ord(ws,wP,rs,rp);

daup('order of the filter:'); N

daup('cutoff frequency:'); wc

[b,a] = cheb1(N,rp,wc);

daup('a'); a

daup('b'); b

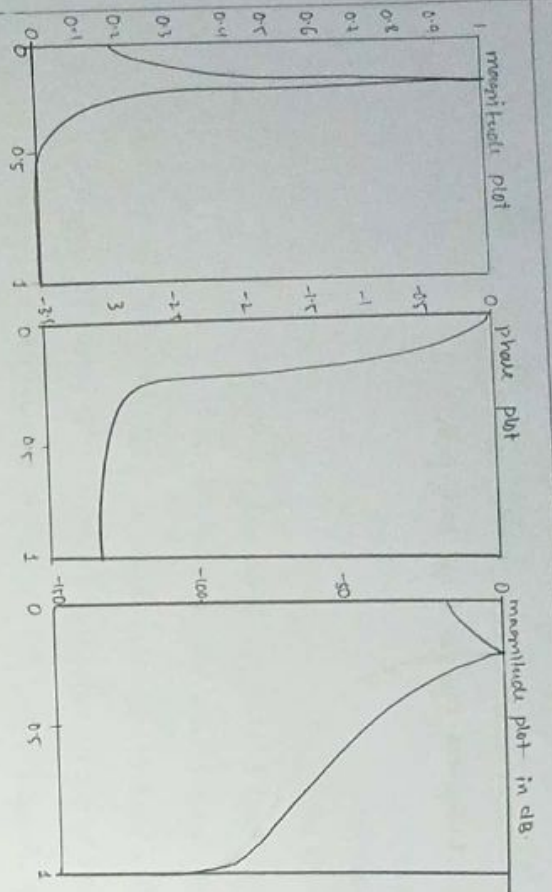
[H,om] = freqz(b,a);

subplot(1,3,1);

plot(1/(2*pi*f),abs(H));

title('magnitude plot');

subplot(1,3,2);



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Plot (Com/pi, angle (H));

title ('phase plot');

subplot (1,3,3);

Plot (Com/pi, 20*log10 (abs(H)));

title ('magnitude plot in dB');

Result:

enter the stopband in dB: 5

enter the passband in dB: 15

enter stopband cutoff frequency: 1000

enter passband cutoff frequency: 1500

enter the sampling frequency: 10000

Order of the filter =

$N = 2$

cutoff frequency

$\omega_c = 0.2000$

$a =$

1.0000 -1.7285 0.9245

$b =$

0.0087 0.0174 0.0087

% Chebyshev type-2 low pass filter

clc;

clear all;

close all;

wp = input('Enter the pass band 'n dB: ');

ws = input('Enter the stop band 'n dB: ');

fp = input('Enter pass cutoff frequency: ');

fs = input('Enter stopband cutoff frequency: ');

f = input('Enter the sampling frequency: ');

wp = 2*pi*fp/f;

ws = 2*pi*fs/f;

[N,wc] = cheb2ord(wp,ws,wp,ws);

disp('Order of the filter: '); N

disp('Cutoff frequency: '); wc

[b,a] = cheb2(N,wp,wc);

disp('a'); a

disp('b'); b

[h,om] = freqz(b,a);

subplot(1,3,1);

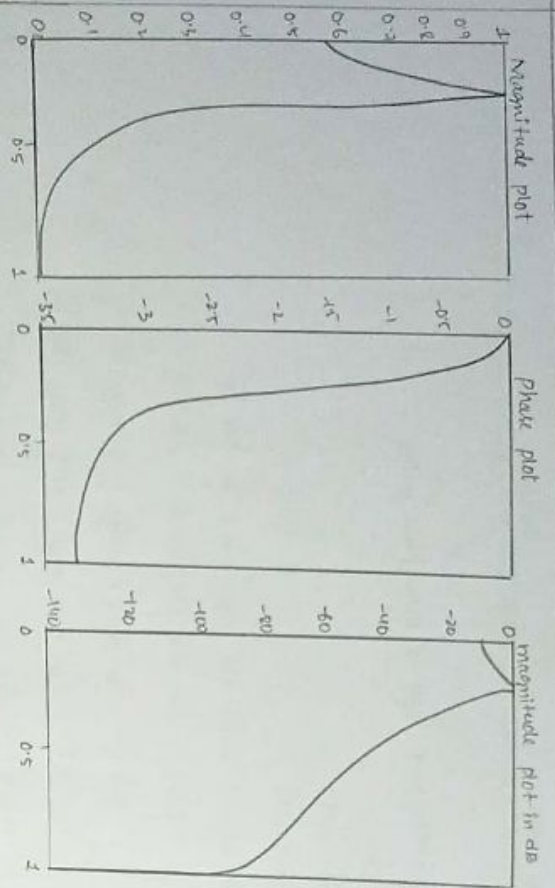
plot(compl(h), abs(h));

title('Magnitude plot');

subplot(1,3,2);

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Plot (Compl, angle (H));

title ('phase plot');

subplot (1,3,3);

plot (om/pi, 20*log10 (abs (H)));

title (' magnitude plot in db ');

Result:

enter the pass band in db: 5

enter the stopband attenuation in db: 15

enter the pass band cutoff frequency: 1000

enter the stopband cutoff frequency: 1500

enter the sampling frequency: 10000

Order of the filter:

N = 2

cutoff frequency

WC = 0.3000

a =

1.0000 -1.2129 0.6646

b =

0.0635 0.1270 0.0635

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%. Chebyshev type-2 high pass filter

clc;

clear all;

close all;

fs = input('enter stopband in dB: ');

wp = input('enter passband in dB: ');

fs = input('enter stopband cutoff frequency');

fp = input('enter passband cutoff frequency');

fc = input('enter the sampling frequency');

ws = 2*pi*fs/f;

wp = 2*pi*fp/f;

[N,wc] = cheb2ord(ws,wp,fs,fp);

disp('order of the filter'); N

disp('cutoff frequency'); wc

[b,a] = cheb2(N,fp,wc);

disp('a'); a

disp('b'); b

[h,om] = freqz(b,a);

subplot(1,3,1);

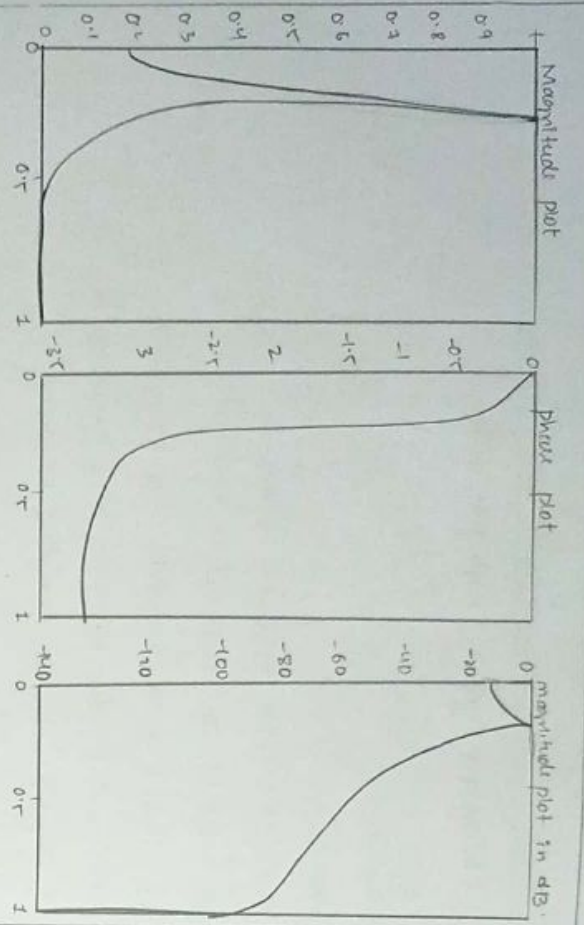
plot(om/pi,abs(h));

title('magnitude plot');

subplot(1,3,2);

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Date

Plot (Compl, avgch);

title ('phase plot');

subplot (1,3,3);

Plot (Compl, 20*log10 (avgch));

title ('magnitude plot in dB');

Result:

cuta stop band in dB: 5

cuta pass band in dB: 15

cuta stopband cutoff frequency: 1000

cuta passband cutoff frequency: 1500

cuta the sampling frequency: 10000

Order of the filter:

N = 2

Cutoff frequency

WC :

0.3000

Q :

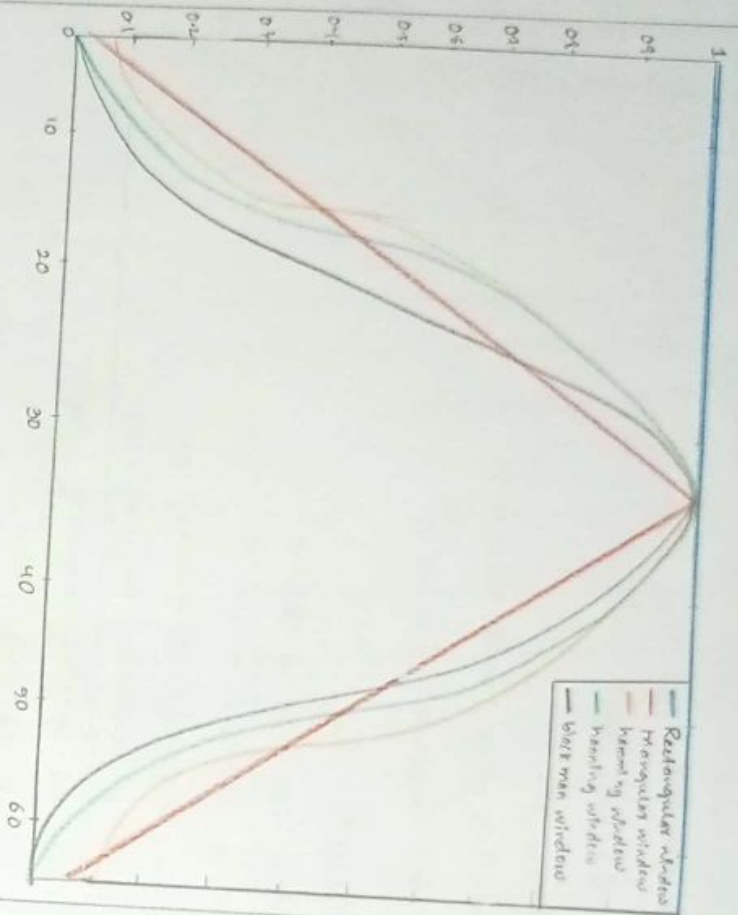
1.0000 -1.4507 0.8916

b :

0.0196 0.0392 0.0196

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Date :

Experiment - 6 FIR FILTERS

∴ Windows for designing FIR filter.

etc.)

clear all;

close all;

$n = 65$;

$w1 = \text{window} (@ \text{rectwin}, n)$;

$w2 = \text{window} (@ \text{triang}, n)$;

$w3 = \text{window} (@ \text{hamming}, n)$;

$w4 = \text{window} (@ \text{hann}, n)$;

$w5 = \text{window} (@ \text{blackman}, n)$;

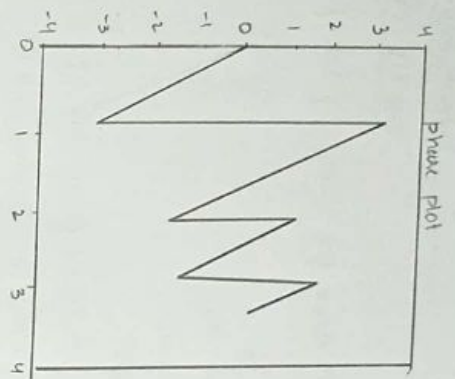
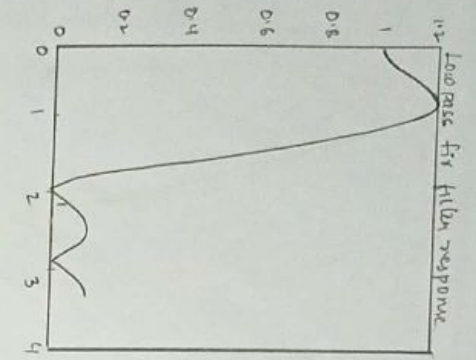
$\text{plot} (1:n, [w1 w2 w3 w4 w5])$;

$\text{axis} ([1, n, 0, 1])$;

legend ('Rectangular window', 'triangular window', 'hamming window', 'hanning window', 'blackman window');

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% FIR FILTERS USING RECTANGULAR WINDOWS.

clc;

clear all;

close all;

% LPF with cutoff frequency 0.5 pi and order = 8.

N = 8;

wc = 0.5*pi;

b = fir1(N, (wc/pi), rectwin(N+1));

dur('s'); b

wco = -0.01 : pi;

H = freqz(b, 1, wco)

subplot(1, 2, 1);

plot(wco, abs(H));

title('Low pass FIR filter response');

subplot(1, 2, 2);

plot(wco, angle(H));

title('Phase plot');

Result:

b =

-0.0000 -0.1148 0.0000 0.3443 0.5409 0.3443 0.0000
-0.1148 -0.0000

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7. HPF with cut-off frequency 0.5π & order=2

$N=2$;

$wc = 0.5\pi$;

$b = \text{hfl}(N, [wc/\pi], 'high', 'rectwin'(N+1))$;

$\text{dhp}('b')$;

$wc0 = -0.001\pi$;

$H = \text{freqz}(b, 1, w)$;

$\text{subplot}(1, 2, 1)$;

$\text{plot}(w, \text{abs}(H))$;

$\text{title}(' \text{high pass filter response}')$;

$\text{subplot}(1, 2, 2)$;

$\text{plot}(w, \text{angle}(H))$;

$\text{title}(' \text{phase plot}')$;

8. BPF with cut-off frequency 0.5π & order=2.

$N=2$;

$wc1 = 0.5\pi$;

$wc2 = 0.6\pi$;

$b = \text{firl}(N, [wc1/\pi, wc2/\pi], 'bandpass', 'rectwin'(N+1))$;

$\text{dhp}('b')$;

$wc0 = -0.001\pi$;

$H = \text{freqz}(b, 1, w)$;

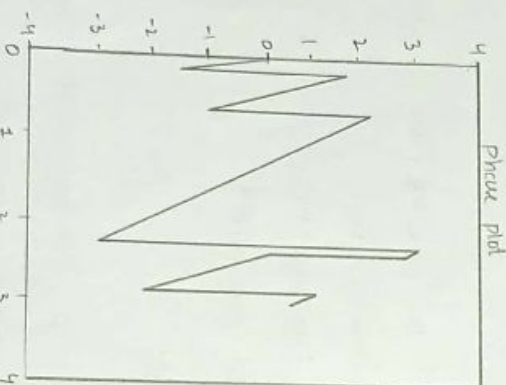
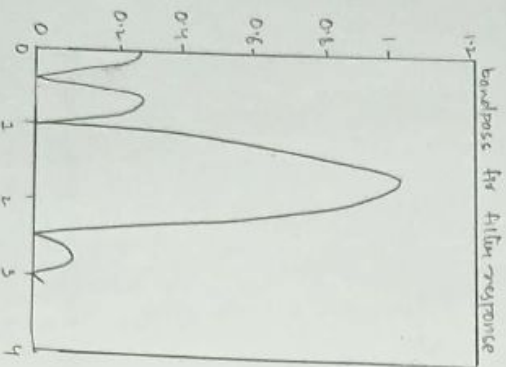
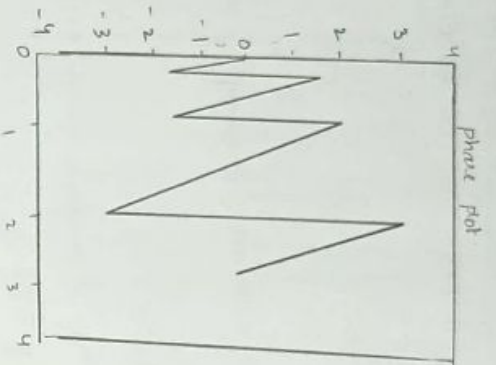
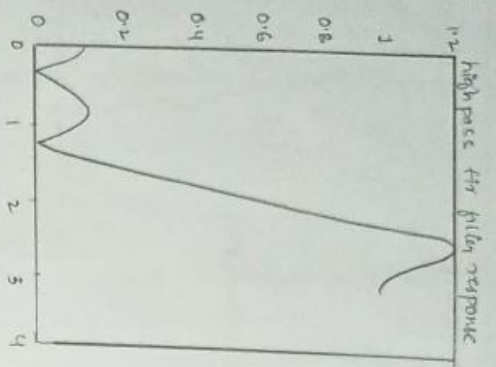
$\text{subplot}(1, 2, 1)$;

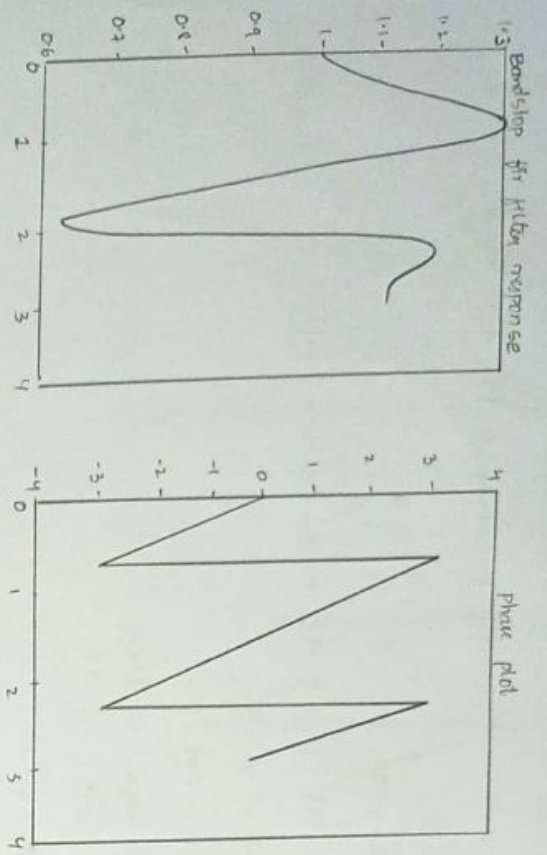
$\text{plot}(w, \text{abs}(H))$;

$\text{title}(' \text{bandpass filter response}')$;

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```
subplot(1,2,2);
plot(w,angle(h));
title('phase plot');
```

Result:

$b =$

```
0.1701 0.2983 -0.2102 -0.0350 0.2247 -0.0350 -0.2102
0.0483 0.1701
```

% BRF with cutoff frequency 0.5 π & order=8.

$N=8$

$wc1 = 0.5\pi$;

$wc2 = 0.6\pi$;

$b = \text{firls}(N, [\text{wc1}/\pi, \text{wc2}/\pi], \text{'stop'}, \text{rechain}(N+1));$

$\text{dimp}(\text{'b'}) ; b$

$wc0 = 0.01 ; \pi$;

$H = \text{freqz}(b,1,w0);$

$\text{subplot}(1,2,1);$

$\text{plot}(\text{w},\text{abs}(H));$

$\text{title}(\text{'bandstop firs filter response'});$

$\text{subplot}(1,2,2);$

$\text{plot}(\text{w},\text{angle}(H));$

$\text{title}(\text{'phase plot'});$

Result:

```
b = -0.0861 -0.0497 0.0104 0.0177 1.0234 0.0177 0.0104 -0.0497 -0.0861
```

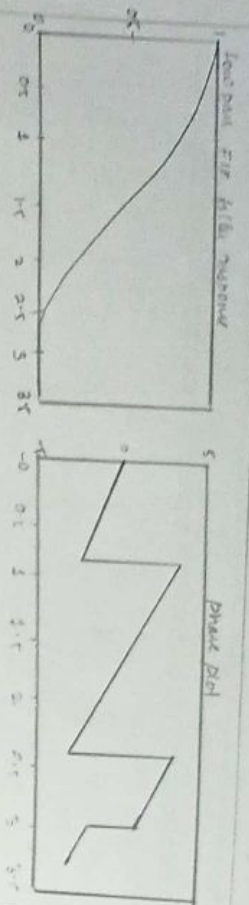
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% FIR filter using hamming window.

% LPF with cutoff frequency 0.5 pi and order=8

clc;

clear all;

close all;

N=8

wc = 0.5 * pi;

b = fir1(N, wc/pi, ^{hamming}rect(N+1));

disp('w'), b

w = 0.5001, pi;

H = freqz(b, 1, w)

subplot(1,2,1);

plot(w, abs(H));

title('Low pass FIR filter response');

subplot(1,2,2);

plot(w, angle(H));

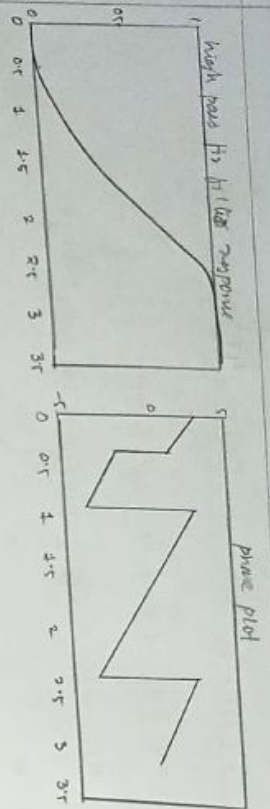
title('Phase Plot');

Result:

b =	-0.0000	-0.0227	0.0000	0.229740	0.4974	0.2740
	0.0000	-0.0227	-0.0000			

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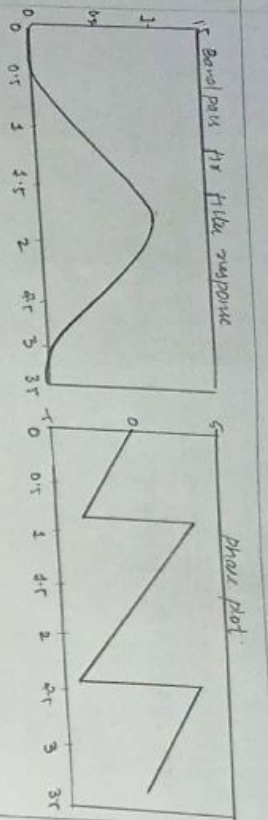
```

clc;
clearall;
closeall;
N=8;
wc=0.5*pi;
b=fir1(N,wc/pi,'high',hamming(N+1));
darp('b'),b
we=0.001*pi;
H=freqz(b,1,we);
subplot(1,2,1);
plot(w,abs(H));
title('high pass filter for response');
subplot(1,2,2);
plot(w,angle(H));
title('phase plot');

```

Result:

b =	-0.0000	0.0227	-0.0000	-0.2740	0.4974	-0.2740
	-0.0000	-0.0227	-0.0000			



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✓ BPF with cutoff frequency 0.5π & order = 8.

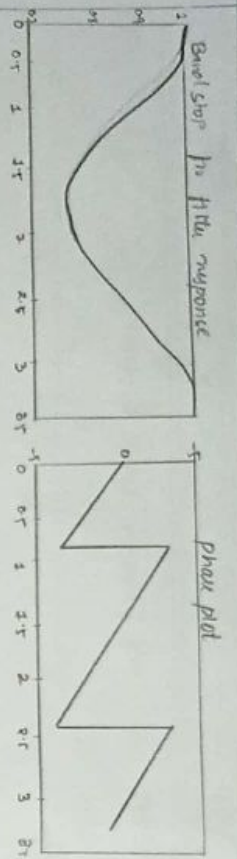
```
clc;
clearall;
closeall;
N = 8;
w1 =  $0.5\pi$ ;
w2 =  $0.6\pi$ ;
b = firls(N, [w1/pi, w2/pi], 'bandpass', hamming(N+1));
dimp('b');
wco = 0.01*pi;
H = freqz(b, 1, w);
subplot(1, 2, 1);
plot(w, abs(H));
title('band pass filter response');
subplot(1, 2, 2);
plot(w, angle(H));
title('phase plot');
```

Result:

b =	0.0274	0.0430	-0.2311	-0.0617	0.4574	-0.0617
	-0.2311	-0.0430				

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Date :

% BPF with cutoff frequency 0.5π & Order=8

clc;

clear all;

close all;

N=8;

w_{x1}=0.5*π;

w_{x2}=0.6*π;

b= firl(N, [w_{x1} π], 'stop', 'hanning', (N+1));

durp('b'); b

N=0:100:π;

H= freqz(b, 1, N);

subplot(1,2,1);

plot(w, abs(H));

title('band stop filter response');

subplot(1,2,2);

plot(w, angle(H));

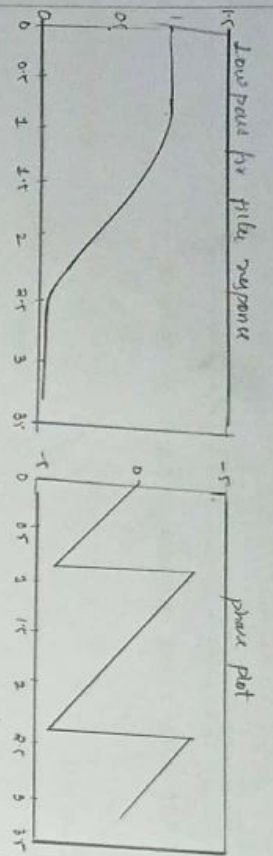
title('Phase plot');

figure;

-0.0061	-0.0094	0.0507	0.0135	0.9026	0.0135
0.0507	-0.0094	-0.0061			

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✓. FIR filter using Triangle window

✓. LPF with cut-off frequency 0.5π and $order=8$.

clc;

clear all;

close all;

$N=8$;

$wc = 0.5 * \pi$;

$b = \text{firl}(N, (wc/\pi), \text{triang}(N+1))$;

$\text{darp}('b')$;

$w = 0:0.01:\pi$;

$H = \text{freqz}(b, 1, w)$;

$\text{subplot}(1, 2, 1)$;

$\text{plot}(C, \text{abs}(H))$;

$\text{title}('Low pass FIR filter response')$;

$\text{subplot}(1, 2, 2)$;

$\text{plot}(C, \text{angle}(H))$;

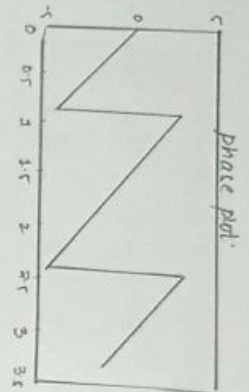
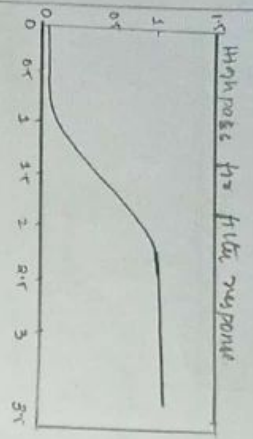
$\text{title}('Phase plot')$;

Result:

$b =$	0.0000	-0.0459	0.0000	0.2755	0.5409	0.2755	0.0000
$C =$	-0.0459	-0.0000					

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% HPF with cutoff frequency 0.5π & order = 8.

clc;

clearall;

closeall;

N = 8;

wc = 0.5 * pi;

bz = firl(N, (wclpi), 'high', 'triang' (N+1));

dbp (bz), b

w = 0 : -0.01 : pi;

H = freqz (bz, 1, w);

subplot (1,2,1);

plot (w, abs(H));

title ('High pass filter response');

subplot (1,2,2);

plot (w, angle (H));

title ('Phase plot');

Result:

-0.0000	0.0459	-0.0000	-0.2455	0.5409	-0.2455
-0.0000	0.0459	-0.0000			

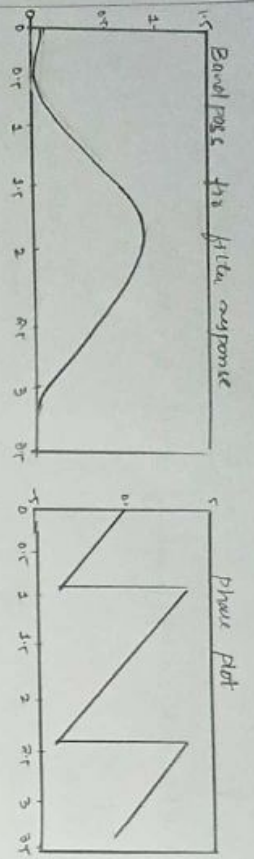
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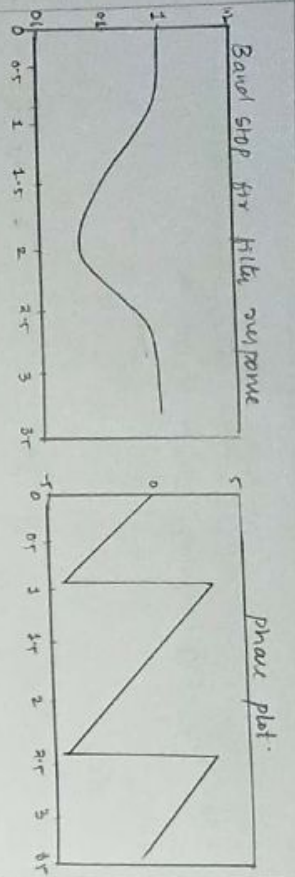
```
%BPF with cutoff frequency 0.5 pi & order = 8
clc;
clear all;
close all;
N=8;
w1=0.5*pi;
w2=0.5*pi;
b=filter(N,[w1*pi w2*pi],'bandpass',length(N+1));
disp('b'); b
wc=0.001*pi;
H=freqz(b,1,wc);
subplot(1,2,1);
plot(w,abs(H));
title('bandpass for filter response');
subplot(1,2,2);
plot(w,angle(H));
title('phase plot');
```

Result:

b =					
0.0603	0.0697	-0.2236	-0.0496	0.3983	-0.0496
-0.2236	0.0697	0.0603			

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Date :

✓. BRF with cutoff frequency 0.5π & order = 8.

clc;

clear all;

close all;

N=8;

$wc = 0.5\pi$;

$wc2 = 0.6\pi$;

$bz = \text{firl}(N, [wc, \pi - wc], 'stop', 'bary' (N+1));$

$dap = ('b')^b$;

$wc = 0.5\pi$;

$H = \text{freqz}(bz, dap, w);$

$\text{subplot}(1, 2, 1);$

$\text{plot}(|w|, \text{abs}(H));$

$\text{title}('band stop filter response');$

$\text{subplot}(1, 2, 2);$

$\text{plot}(|w|, \text{angle}(H));$

$\text{title}('phase plot');$

Result:

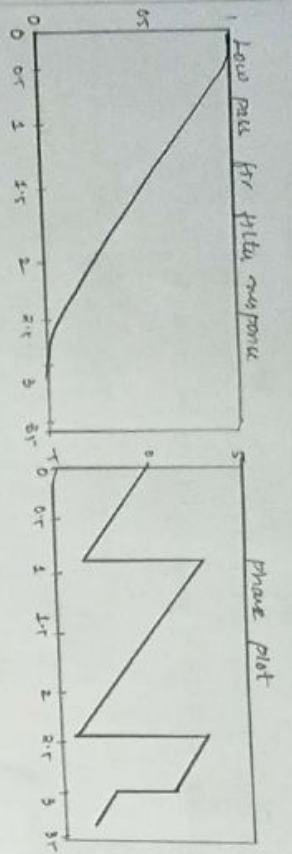
$bz =$

-6.6156 -6.0180 0.0578 0.0128 0.926 0.0128 0.0578

-0.0180 -0.0156

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Date :

✓. FIR filter using hamming window
 ✓. LPF with cutoff frequency 0.5 pi and order=8.

clc;

clear all;

close all;

N=8

wc = 0.5*pi;

b = fird (N,wc/pi, ham (N+1));

dbp ('b'); b

w = 0: .001: pi;

H = freqz (b,1,w);

subplot (1,2,1);

plot (w,abs (H));

title ('Low pass FIR filter response');

subplot (1,2,2);

plot (w,angle (H));

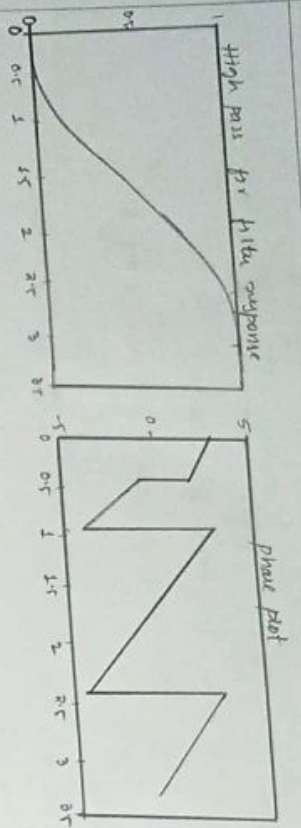
title ('phase plot');

Result

b:	-0.0793	0.0000	0.2684	0.4939	0.0000	-0.0153
	0.0000	-0.0153	0.0000	0.2684	0.4939	0.0000
	0.0000					

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Date :

% HPF with cutoff frequency 0.5 pi & order = 8

clc;

clear all;

close all;

N=8;

w=0.5*pi;

b= fir1 (N, w, 'high', 'hann (N+1));

disp ('b'); b

w= 0.5001 : pi;

h= freqz (b, 1, w);

subplot (1,2,1);

plot (w, abs(h));

title ('high pass filter response');

subplot (1,2,2);

plot (w, angle(h));

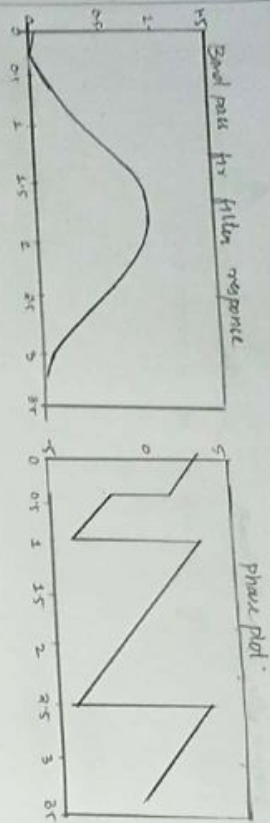
title ('phase plot');

Result:

b=	0.0000	0.0153	-0.0000	-0.2684	0.4939	-0.2684
	-0.0000	0.0153	0.0000			

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Page No. 53

Date :

1. BPF with cutoff frequency $0.5\pi \leq \omega < 0.6\pi$

clc;

clear all;

close all;

N=8;

$\omega_1 = 0.5\pi$;

$\omega_2 = 0.6\pi$;

b = firl(N, [w1/pi w2/pi], 'bandpass', 'hann(N+1));

dbp(b);

w = 0:0.01:pi;

H = freqz(b, 1, w);

subplot(1,2,1);

plot(w, abs(H));

title('band pass filter response');

subplot(1,2,2);

plot(w, angle(H));

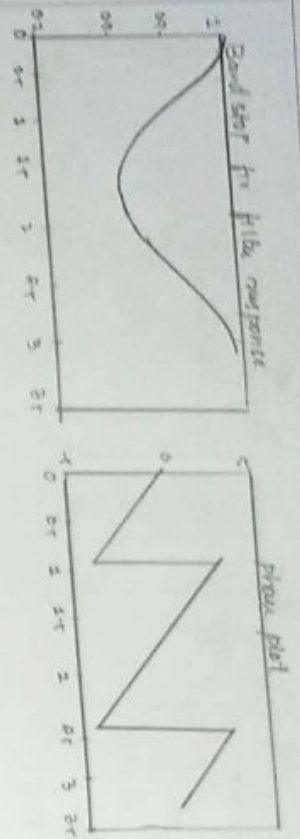
title('phase plot');

Result

b =	0.0000	0.0322	-0.2351	-0.0668	0.5026	-0.0668
	-0.2351	0.0322	0.0000			

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1. BRF with cut off frequency 0.5π & order = 8

clc;

clear all;

close all;

N=8;

$w_1 = 0.5\pi$;

$w_2 = 0.6\pi$;

$b = \text{firl}(N, [w_1/\pi, w_2/\pi], 'stop', \text{hann}(N+1));$

$\text{darp}('b'); b$

$w = 0:0.01:\pi$;

$4 * \text{freqz}(b, 1, w);$

$\text{subplot}(1, 2, 1);$

$\text{plot}(w, \text{abs}(H));$

$\text{title}('band stop for filter response');$

$\text{subplot}(1, 2, 2);$

$\text{plot}(w, \text{angle}(H));$

$\text{title}('phase plot');$

Result:

b_1	0.0000	-0.0064	0.0464	0.0132	0.4934	0.0132
b_8	0.0464	-0.0064	0.0000			

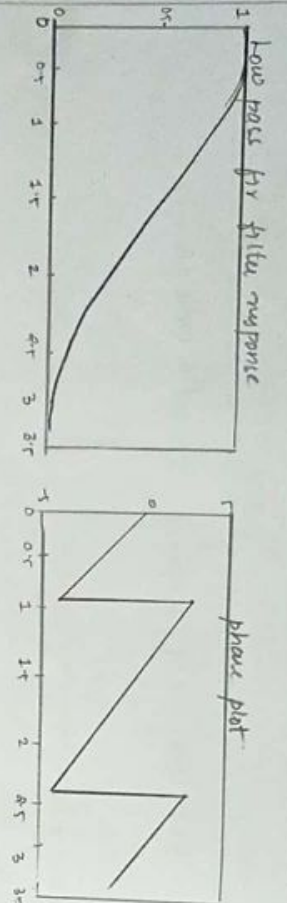
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9. FIR filter using Blackman window.
 71PF with cutoff frequency 0.5π and order=8

```

clc;
clear all;
close all;
N=8;
wc = 0.5*pi;
b = fir1(N, (wc/pi), 'blackman(N+1));
darp('b'), b
w = 0:-0.001:pi;
H = freqz(b, 1, w);
subplot(1, 2, 1);
plot(w, abs(H));
title('low pass FIR filter response');
subplot(1, 2, 2);
plot(w, angle(H));
title('phase plot');

```

Result:

b =	-0.0072	0.0000	0.2514	0.511	0.2514	0.0000
	-0.0072	0.0000				

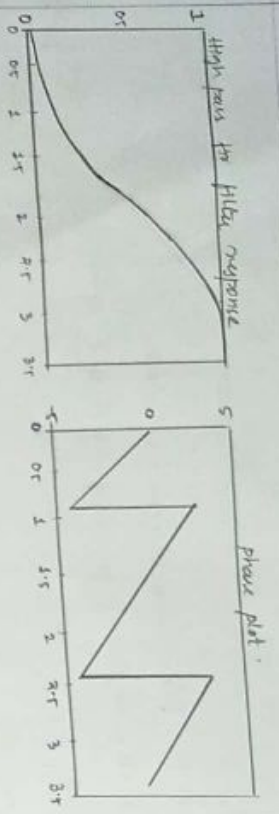
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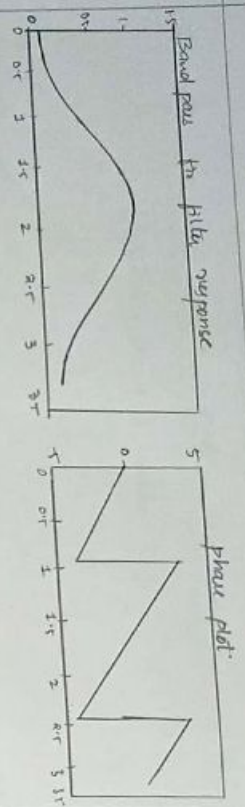


4. HTPF with cutoff frequency 0.5π & order = 8

```
clc;
clear all;
close all;
N=8;
wc = 0.5*pi;
b = firls(N, [wclpi, 'high', 'blackman(N+1)]);
darp('b');b;
w=0:-0.01:pi;
H = freqz(b,1,w);
subplot(1,2,1);
plot(w,abs(H));
title('high pass filter response');
subplot(1,2,2);
plot(w,angle(H));
title('phase plot');
```

Result:

b =									
0.0000	0.0042	-0.0000	-0.2514	0.5111	-0.2514	-0.0000			
0.0042	0.0000								



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4. BPF with cut off frequency 0.5π & Order = 8

clc;

clear all;

close all;

N=8;

$wc_1 = 0.5\pi$; %

$wc_2 = 0.6\pi$; %

$b = \text{firls}(N, [wc_1/\pi, wc_2/\pi], 'bandpass', \text{blksam}(N+1))$;

$\text{darp}(b)$; %

$w = 0:0.001:\pi$;

$H = \text{freqz}(b, 1, w)$;

$\text{subplot}(1, 2, 1)$;

$\text{plot}(w, \text{abs}(H))$;

$\text{title}('band pass filter response')$;

$\text{subplot}(1, 2, 2)$;

$\text{plot}(w, \text{angle}(H))$;

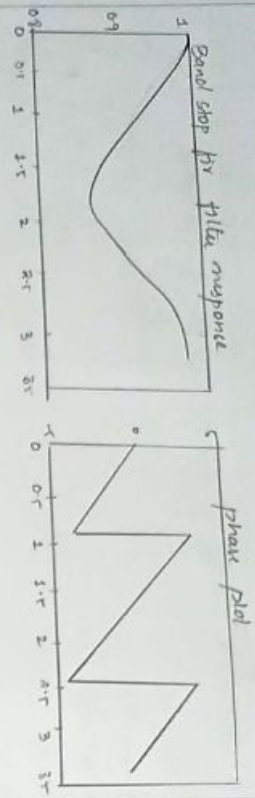
$\text{title}('phase plot')$;

Result:

$b =$	0.0000	0.0144	-0.1906	-0.0722	0.5991	-0.0722
	-0.1906	0.0144	0.0000			

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V. BKF with cutoff frequency 0.5π & order=8;

clc;

clear all;

close all;

~~N~~ N=8;

$\omega_c = 0.5\pi$;

$\omega_c = 0.6\pi$;

b = fir1(N, [wcl/pi wcu/pi], 'stop', 'bilinear', N+1);

abs(b), b

wc=0:0.01:pi;

H = freqz(b,1,w);

subplot(1,2,1);

plot(w,abs(H));

title('Band stop fir filter response');

subplot(1,2,2);

plot(w,angle(H));

title('Phase plot');

Result:

b =					
0.0000	-0.0030	0.0324	0.0123	0.9166	0.0123
0.0324	-0.0030	0.0000			