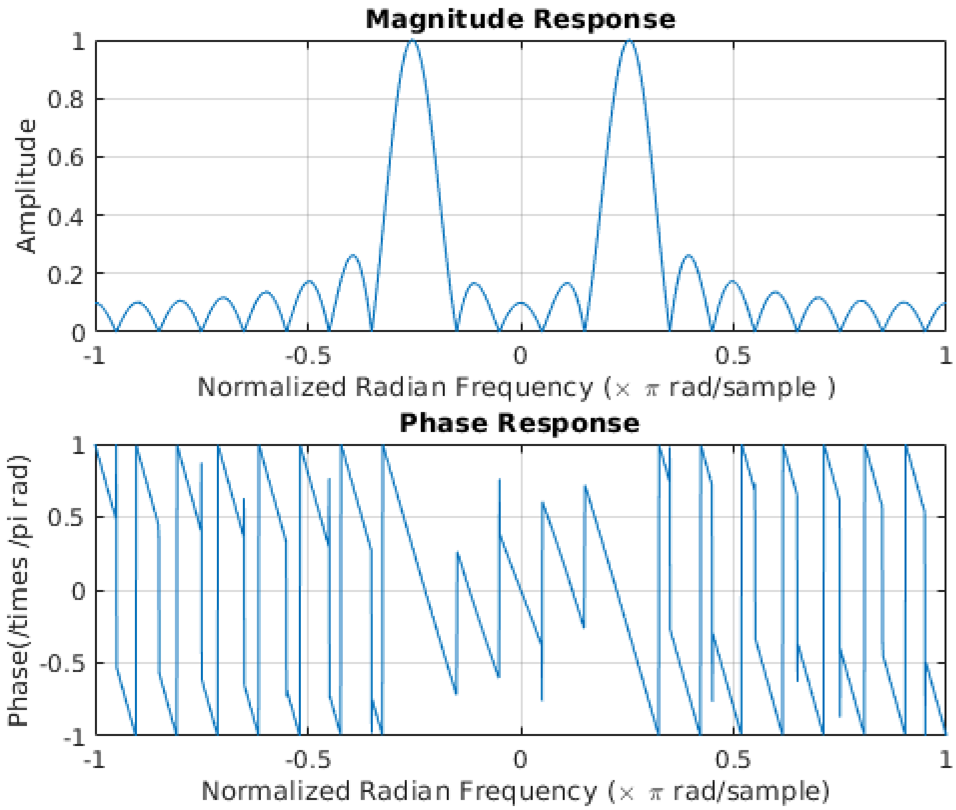
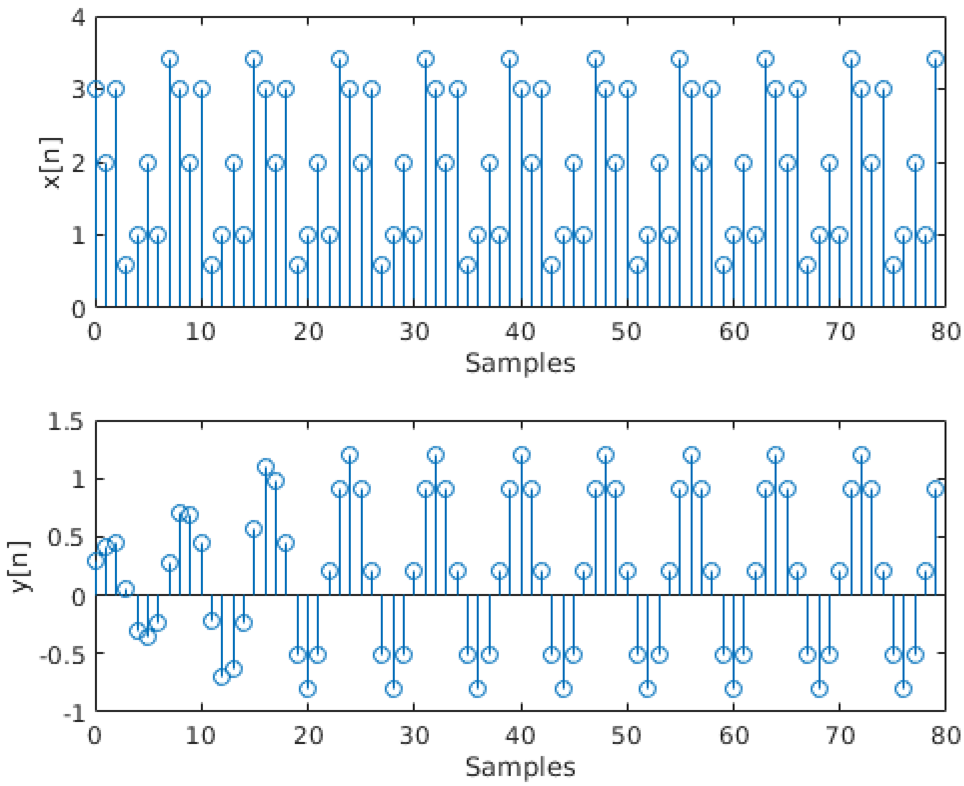
Exercise 5.1

```
%a

type freq_resp.m

%b

type gen_filter

%c

w0 = pi/4;
L = 20;
w = -pi:pi/1000:pi;
b = gen_filter(w0,L);
H = freq_resp(b,w);

figure(1) ;
subplot (2 , 1 , 1)
plot (w/pi,abs(H)) ;
grid on ;
title ( 'Magnitude Response')
xlabel ( 'Normalized Radian Frequency (\times \pi rad/sample ) ') ;
ylabel ( ' Amplitude ') ;
subplot (2 , 1 , 2)
plot ( w / pi , angle ( H ) / pi ) ;
grid on ;
title ( ' Phase Response ')
xlabel ( 'Normalized Radian Frequency (\times \pi rad/sample) ');
ylabel('Phase(/times /pi rad)');
% The magnitude response reaches it's max value at the radian
 frequency of
% 0.256

% d

% y[n] = SUM (k = 0:L-1) b(k) * X[n-k]

%e
x = zeros(1,80);
xtemp = 0;
for n = 0:79
    xtemp = xtemp + (2 + cos((pi/4) * (n)) + cos((3*pi/4) * (n) ...
        + (pi/2)));
    x(n+1) = xtemp;
    xtemp = 0;
end


y = filter(b,1,x);
```

```
figure(2)
ns = [0:79];
subplot(2,1,1)
stem(ns,x);
xlabel('Samples');
ylabel('x[n]');

subplot(2,1,2)
stem(ns,y);
xlabel('Samples');
ylabel('y[n]');

% The output plot matches the equation provided in d


function H = freq_resp(b , w)
H = zeros(size(w));
for c = 1:length(b)
    H = H + ( b(c)* exp(-c*1i*w));
end



function b = gen_filter(w0, L)
b_unit_gain = zeros(1,L);
for k = 0:L-1
    b_unit_gain(k+1) = cos(w0*k);
end
w = -pi:pi/1000:pi;
H = freq_resp(b_unit_gain, w);
max_mag = max(abs(H));
b = b_unit_gain / max_mag;
```



Magnitude Response
Amplitude
Normalized Radian Frequency (× π rad/sample)
Phase Response
Phase(/times /pi rad)
Normalized Radian Frequency (× π rad/sample)



Exercise 5.2

```
%a
type gen_filter_w_info

[b,f_start, f_end, bw] = gen_filter_w_info(pi/4,20);
f_start
f_end
bw

%b

[b, f_start, f_end, bw] = gen_filter_w_info(pi/4,40);
f_start
f_end
bw

% bandwidth doubles as length halves


%c

% function to get rad/samp from hz

type getRadSamp
```

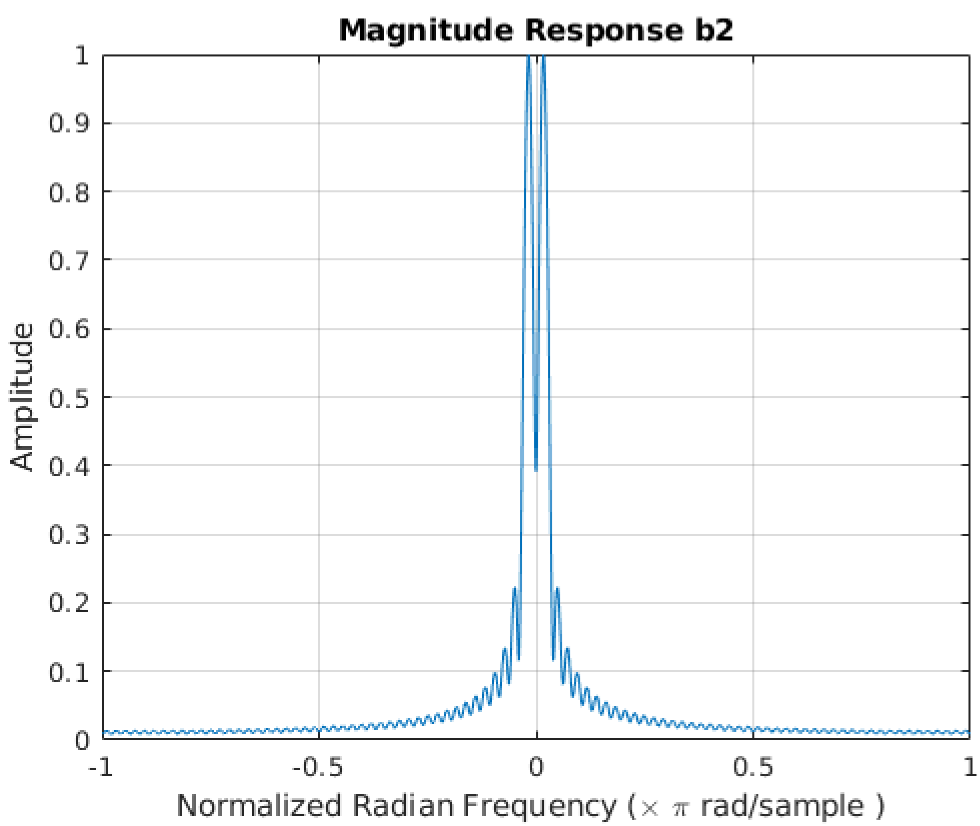
```
% Octave : 2 3 4 5 6 7
% Start key # : 36 48 60 72 84 96
% End key # : 47 59 71 83 95 107
% Start freq ( Hz ) : 65.4 130.8 261.6 523.3 1046.5 2093.0
% End freq ( Hz ) : 123.5 246.9 493.9 987.8 1987.5 3951.1
% Center freq ( Hz ) : 94.4 188.9 379.2 755.5 1551.0 3022.0
% Start freq ( rad/sample ) : 0.0373 0.0745 0.1490 0.2981 0.5961
 1.1922
% End freq ( rad/sample ) : 0.0703 0.1406 0.2813 0.5627 1.1321 2.2506
% Center freq ( rad/sample ) : 0.0538 0.1076 0.2160 0.4303 0.8835
 1.7214


%d


type guessL

w = -pi:pi/1000:pi;

[b2,f_start,f_end, bw] = gen_filter_w_info(0.0538 ,round...
    (guessL(0.0538,20,0.703,0.0373)));
f_start
f_end

H = freq_resp(b2,w);

figure(3) ;
plot (w/pi,abs(H)) ;
grid on ;
title ( 'Magnitude Response b2')
xlabel ( 'Normalized Radian Frequency (\times \pi rad/sample ) ') ;
ylabel ( ' Amplitude ') ;

[b3,f_start,f_end, bw] = gen_filter_w_info(0.1076 ,round...
    (guessL(0.1076,20,0.1406,0.0745)));
f_start
f_end

H = freq_resp(b3,w);

figure(4) ;
plot (w/pi,abs(H)) ;
grid on ;
title ( 'Magnitude Response b3')
xlabel ( 'Normalized Radian Frequency (\times \pi rad/sample ) ') ;
ylabel ( ' Amplitude ') ;

[b4,f_start,f_end, bw] = gen_filter_w_info(0.2160 ,round...
    (guessL(0.2160,20,0.2813,0.1490)));
f_start
f_end
```

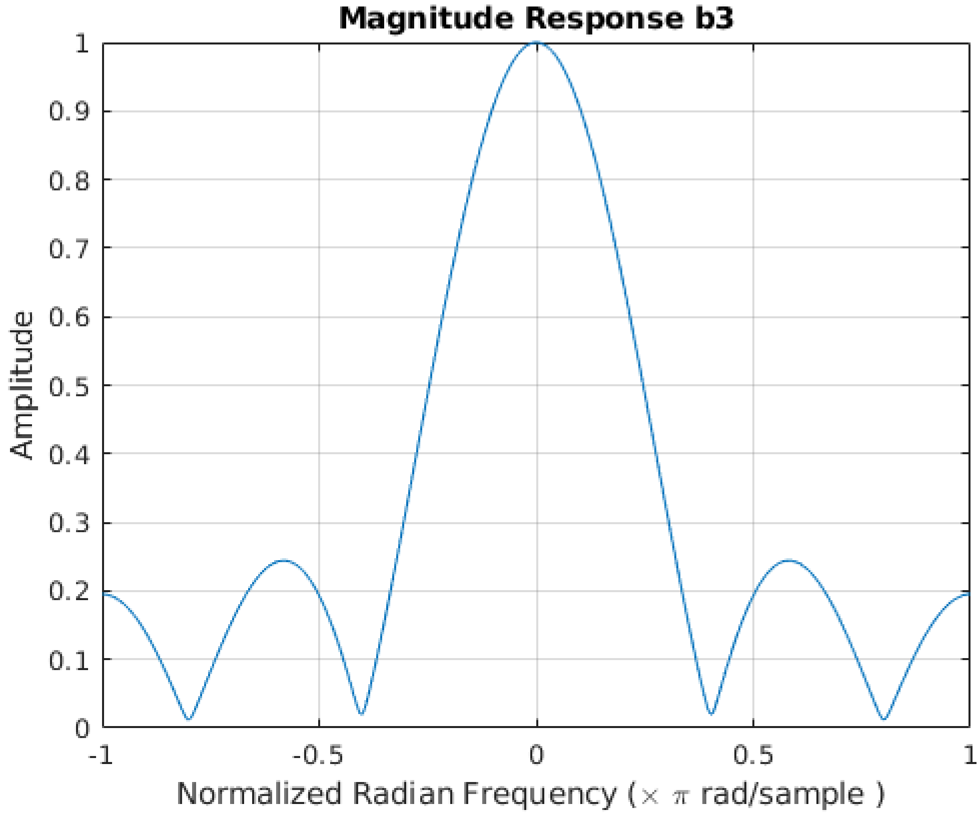
```
H = freq_resp(b4,w);

figure(5) ;
plot (w/pi,abs(H)) ;
grid on ;
title ( 'Magnitude Response b4')
xlabel ( 'Normalized Radian Frequency (\times \pi rad/sample ) ') ;
ylabel ( ' Amplitude ') ;

[b5,f_start,f_end, bw] = gen_filter_w_info(0.4303 ,round...
    (guessL(0.4303,20,0.5627 ,0.2981)));
f_start
f_end

H = freq_resp(b5,w);

figure(6) ;
plot (w/pi,abs(H)) ;
grid on ;
title ( 'Magnitude Response b5')
xlabel ( 'Normalized Radian Frequency (\times \pi rad/sample ) ') ;
ylabel ( ' Amplitude ') ;

[b6,f_start,f_end, bw] = gen_filter_w_info(0.8835  ,round...
    (guessL(0.8835 ,20,1.1321,0.5961)));
f_start
f_end

H = freq_resp(b6,w);

figure(7) ;
plot (w/pi,abs(H)) ;
grid on ;
title ( 'Magnitude Response b6')
xlabel ( 'Normalized Radian Frequency (\times \pi rad/sample ) ') ;
ylabel ( ' Amplitude ') ;


[b7,f_start,f_end, bw] = gen_filter_w_info(1.7214  ,round...
    (guessL(1.7214 ,20,2.2506,1.1922)));
f_start
f_end

H = freq_resp(b7,w);

figure(8) ;
plot (w/pi,abs(H)) ;
grid on ;
title ( 'Magnitude Response b7');
xlabel ( 'Normalized Radian Frequency (\times \pi rad/sample ) ') ;
ylabel ( ' Amplitude ') ;

%e
[xwav,fs] = audioread('x-file.wav');
```

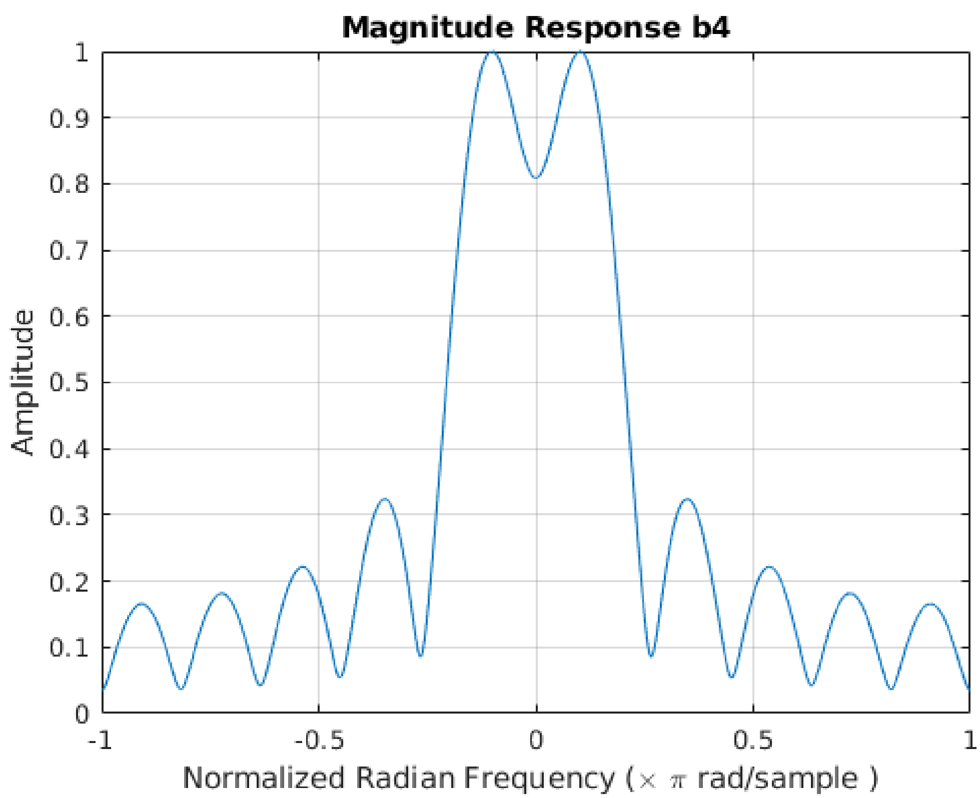
```
xmod = filter(b3,1,xwav);
audiowrite('x-file-octave3.wav',xmod,fs);
% The audio is filtered and seems to be lower in volume as less signal
% gets through

xmod = filter(b7,1,xwav);
audiowrite('x-file-octave7.wav',xmod,fs);
% The audio is even more filtered and
%seems to be even lower in volume as less signal
% gets through the filter


function [b, f_start, f_end, bw] = gen_filter_w_info(w0, L)
w = -pi:pi/1000:pi;
b = gen_filter(w0,L);
H = freq_resp(b, w);
index_passband = find(abs(H) >= 0.7071);
w_passband = w(index_passband);
w_passband_positive = w_passband(find(w_passband >= 0));
f_start = min(w_passband_positive);
f_end = max(w_passband_positive);
bw = f_end - f_start;
end


f_start =

    0.6629


f_end =

    0.9362


bw =

    0.2733


f_start =

    0.7194


f_end =

    0.8577


bw =

    0.1382
```

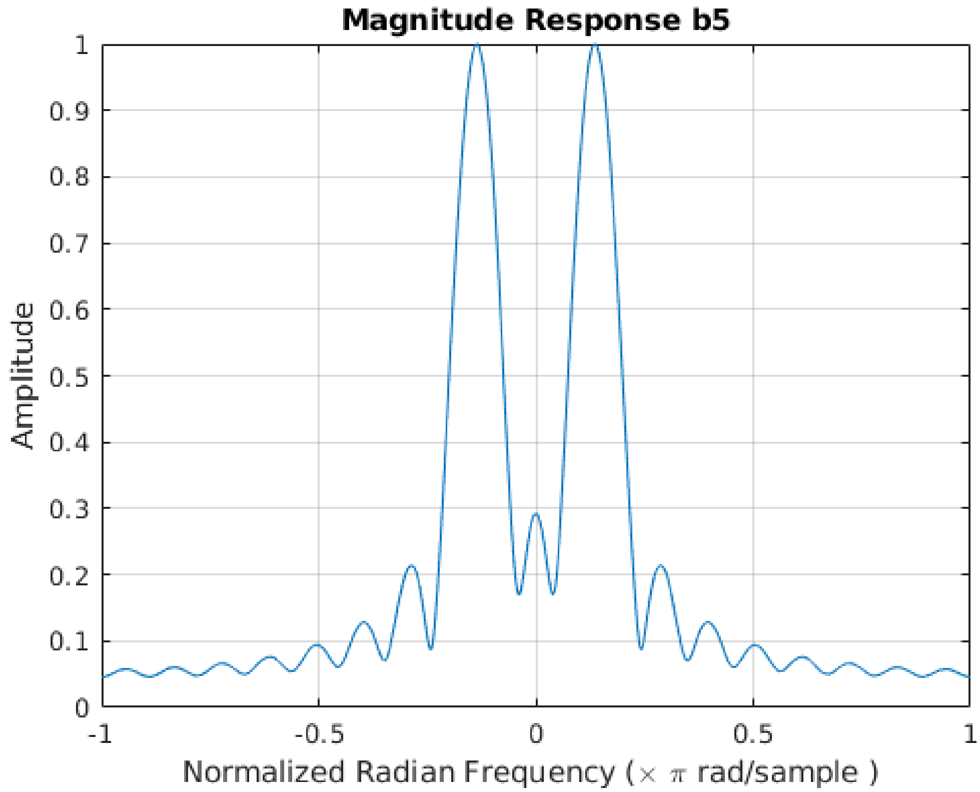
```
function x = getRadSamp(h)
x = h * 6.28 * (1/11025);
end


function x = guessL(w0,g,en,st)
% function to try and guess L for a certain end and start taking
 advantage
% of the linearity of the relationship between L and bw
[b, fs, fe , bw] = gen_filter_w_info(w0,g);
x = (g*(en - st))/bw;


f_start =

    0.0251


f_end =

    0.0848


f_start =

     0


f_end =

    0.5686


f_start =

     0


f_end =

    0.5623


f_start =

    0.2859


f_end =

    0.5718
```

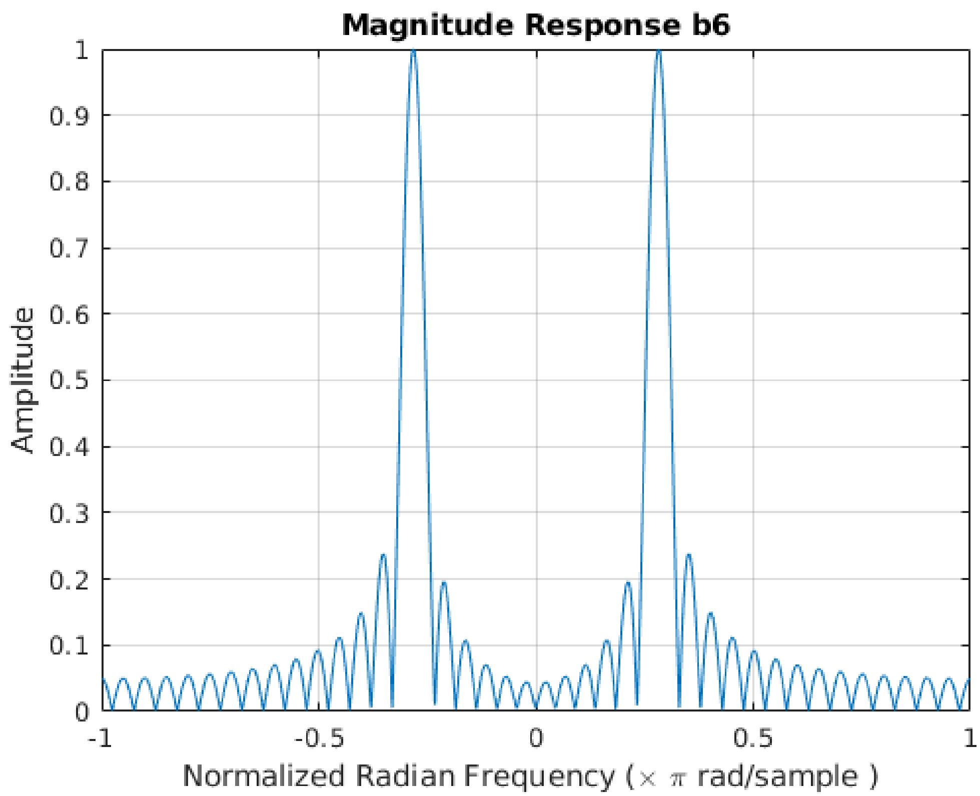
```
f_start =

    0.8200


f_end =

    0.9519


f_start =

    1.6870


f_end =

    1.7562
```

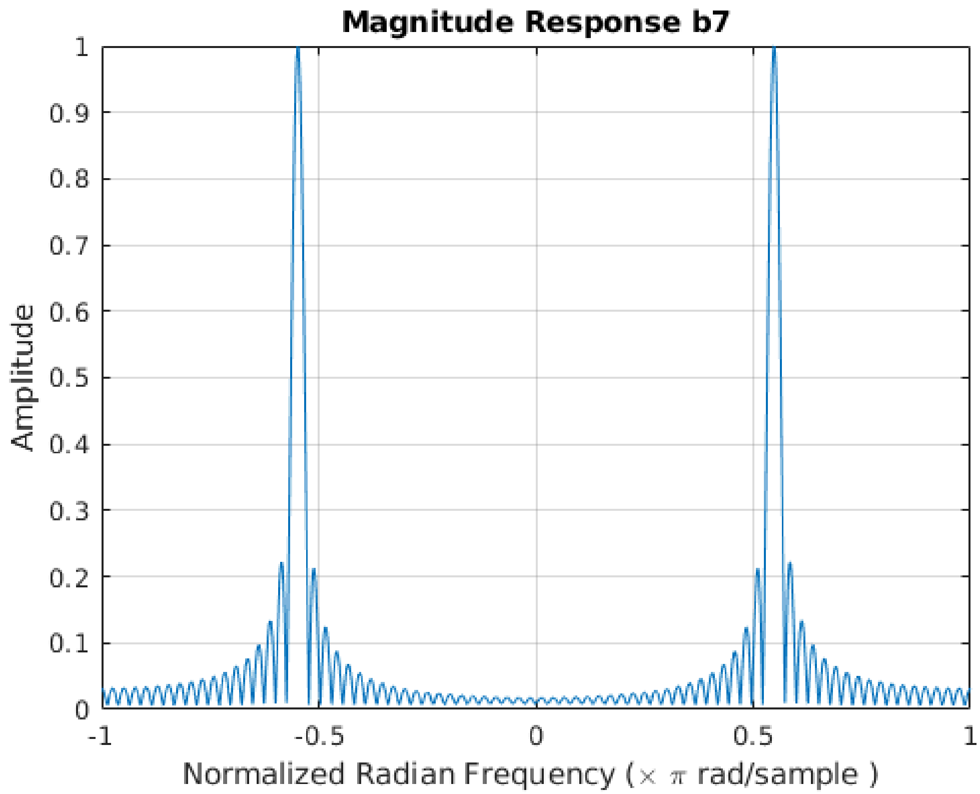



Magnitude Response b3
Amplitude
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-1
-0.5
0
0.5
1
Normalized Radian Frequency (× π rad/sample)


Magnitude Response b4
Amplitude
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-1
-0.5
0
0.5
1
Normalized Radian Frequency (× π rad/sample)


Magnitude Response b5
Amplitude
Normalized Radian Frequency (× π rad/sample)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-1
-0.5
0
0.5
1


Magnitude Response b6
Amplitude
Normalized Radian Frequency (× π rad/sample)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-1
-0.5
0
0.5
1



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