
Problem 3

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Defining input signals and filter H

```
clearvars
close all
h=fir1(100,0.5,'low');
[x1,Fs1] = audioread('x1.mp4');
[x2,Fs2]=audioread('x2.mp4');
% Note that Fs1=Fs2. They can thus be used interchangeably
% Also note that x1 and x2 are of equal length
Fs=Fs1; % or equal to Fs2
len=length(x1); % or length(x2)
```

For System-1

Plotting the frequency response of input signals

```
figure
freqz(x1)
title('System-1: Frequency response of x_1')
figure
freqz(x2)
title('System-1: Frequency response of x_2')

% Multiplying x2 with (-1)^n
x22=zeros(len,1);
for k=1:length(x2)
    x22(k) = (-1)^(k-1) * x2(k);
end

z=x1+x22;
figure
freqz(z)
title('System-1: Frequency response of z')

%Multiplying sum with (-1)^n
z2=zeros(len,1);
for k=1:length(z)
    z2(k) = (-1)^(k-1) * z(k);
```

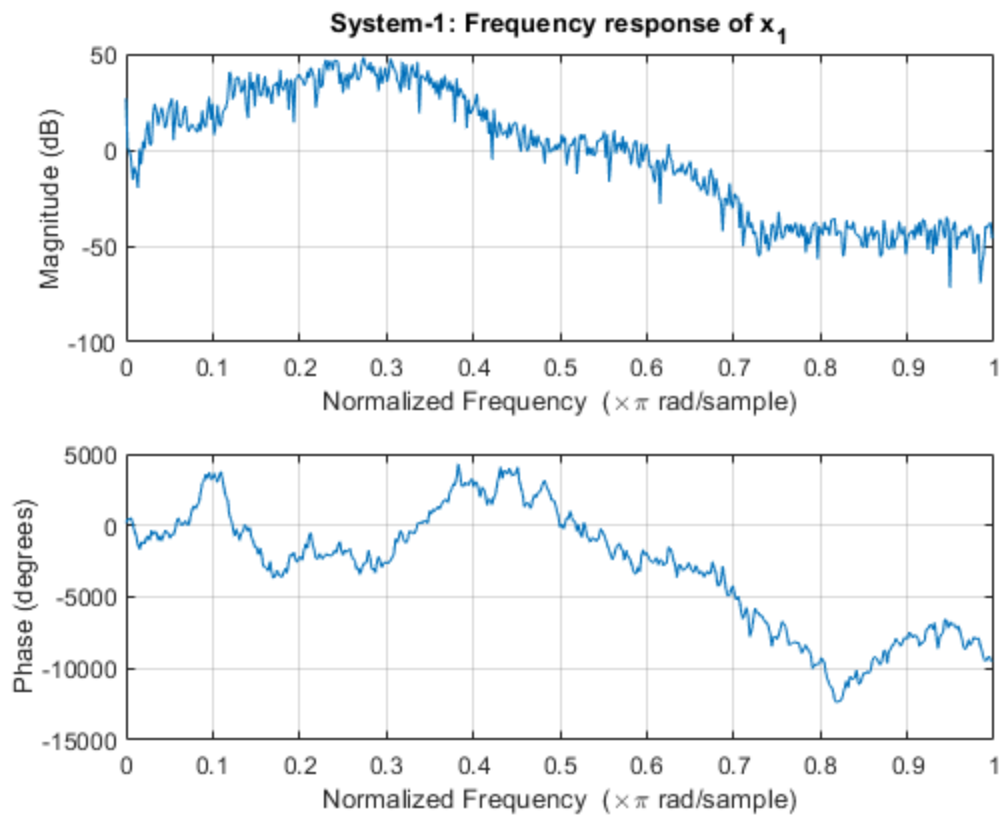
```

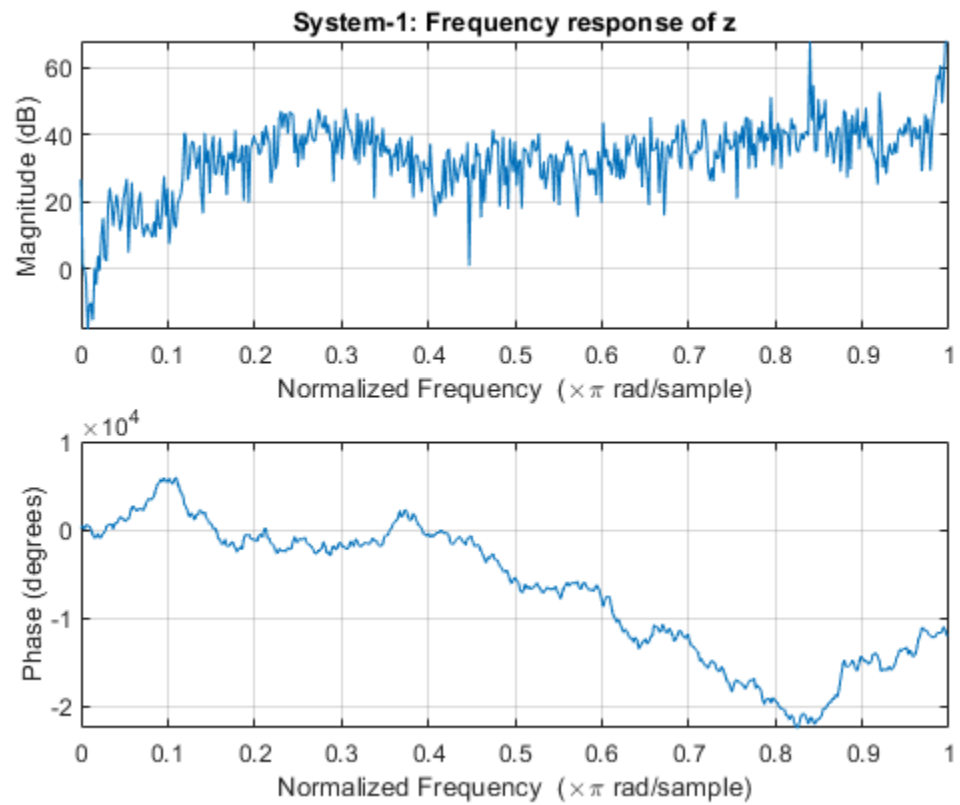
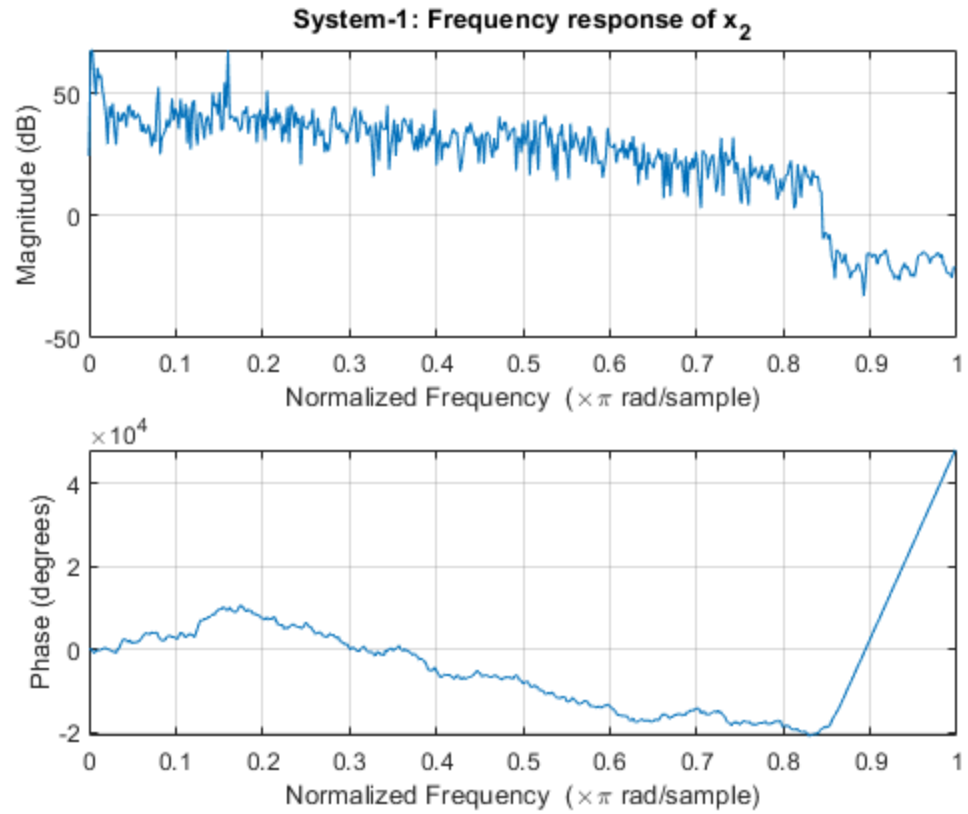
end
% Output signals
y1(:,1)=conv(h,z);
y2(:,1)=conv(h,z2);

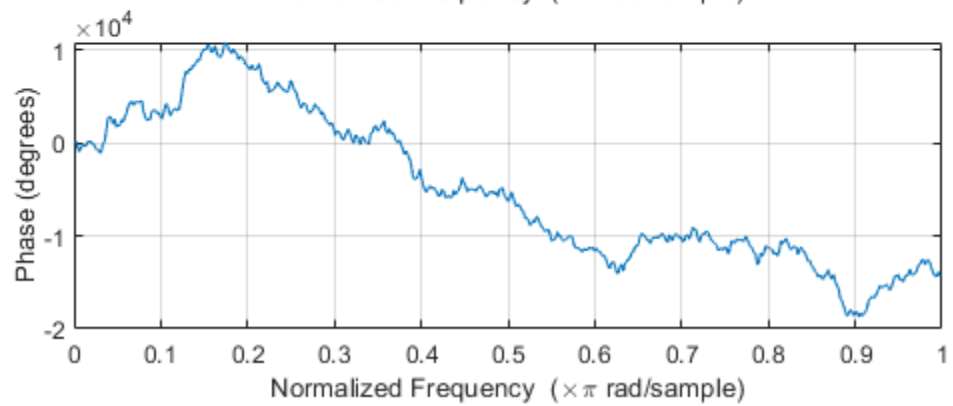
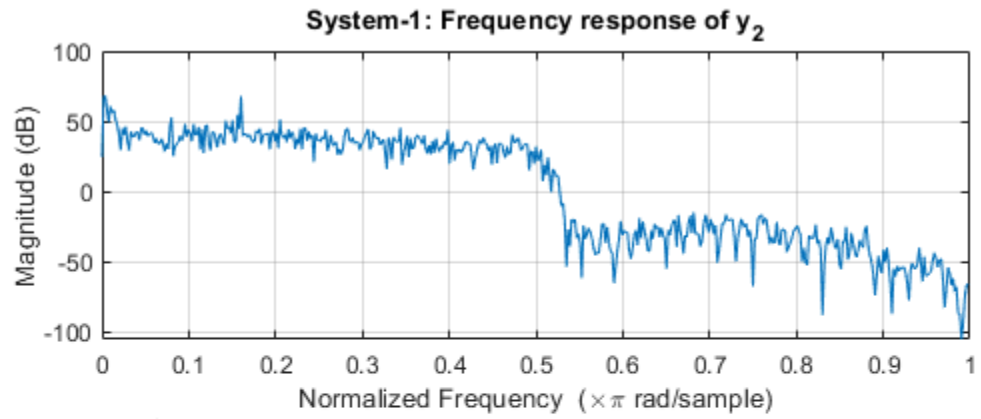
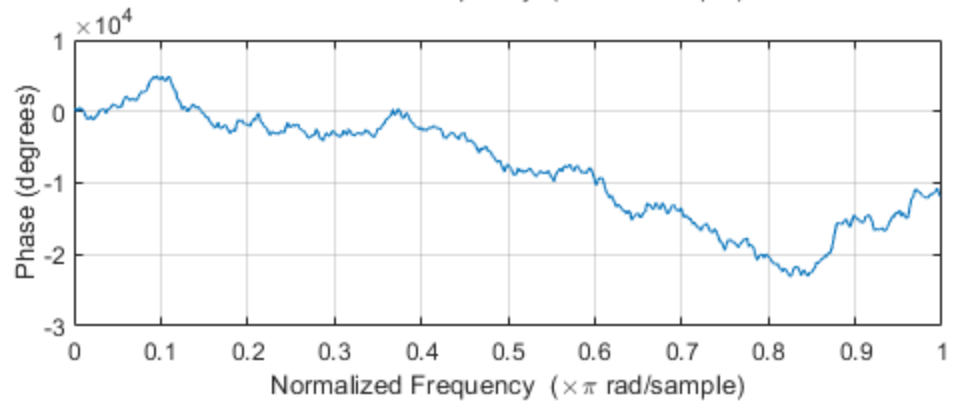
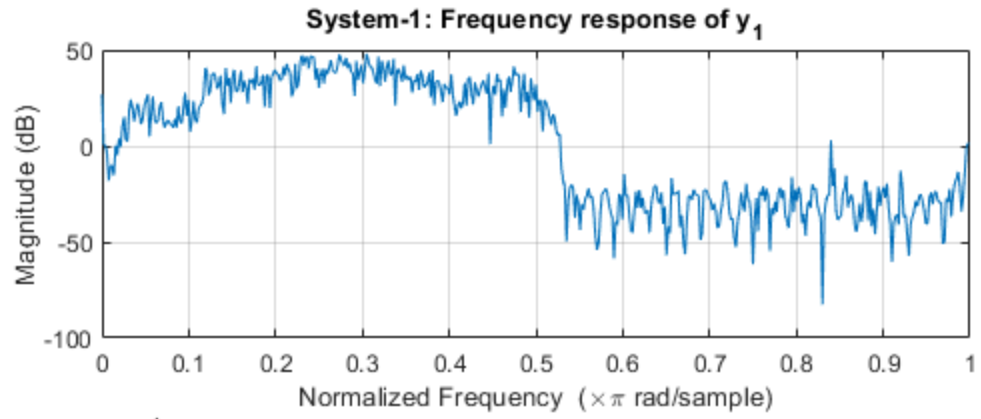
figure
freqz(y1)
title('System-1: Frequency response of y_1')
figure
freqz(y2)
title('System-1: Frequency response of y_2')

% To listen
sound(z,Fs)
pause(30)
sound(y1,Fs)
pause(30)
sound(y2,Fs)
pause(30)

```







For System-2

```
clear y1 y2 z
%Convolving audio signal with LPF
x1_new(:,1)=conv(h,x1);
x2_new(:,1)=conv(h,x2);

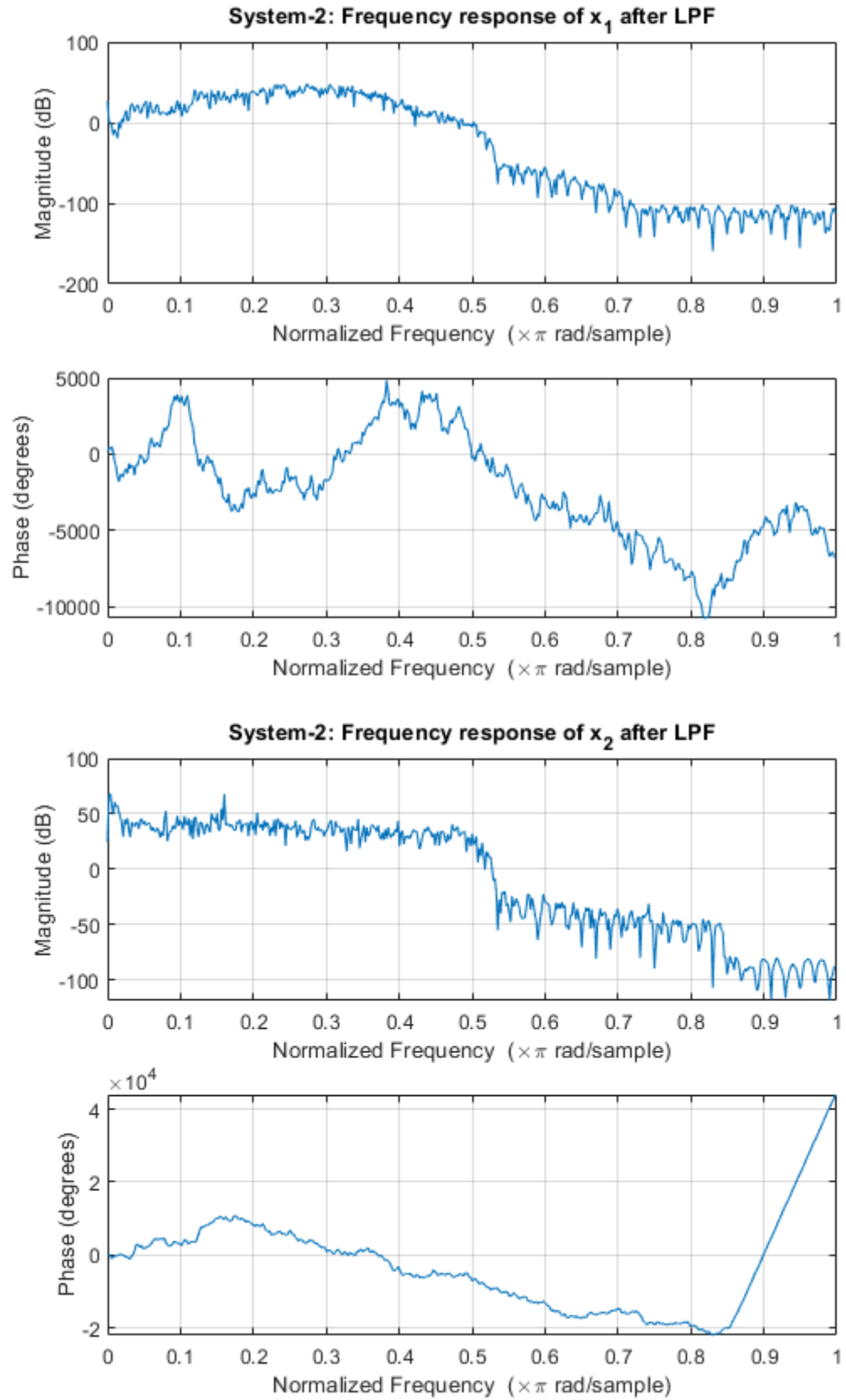
% Plotting the frequency response of input signals
figure
freqz(x1_new) % First channel alone
title('System-2: Frequency response of x_1 after LPF')
figure
freqz(x2_new)
title('System-2: Frequency response of x_2 after LPF')

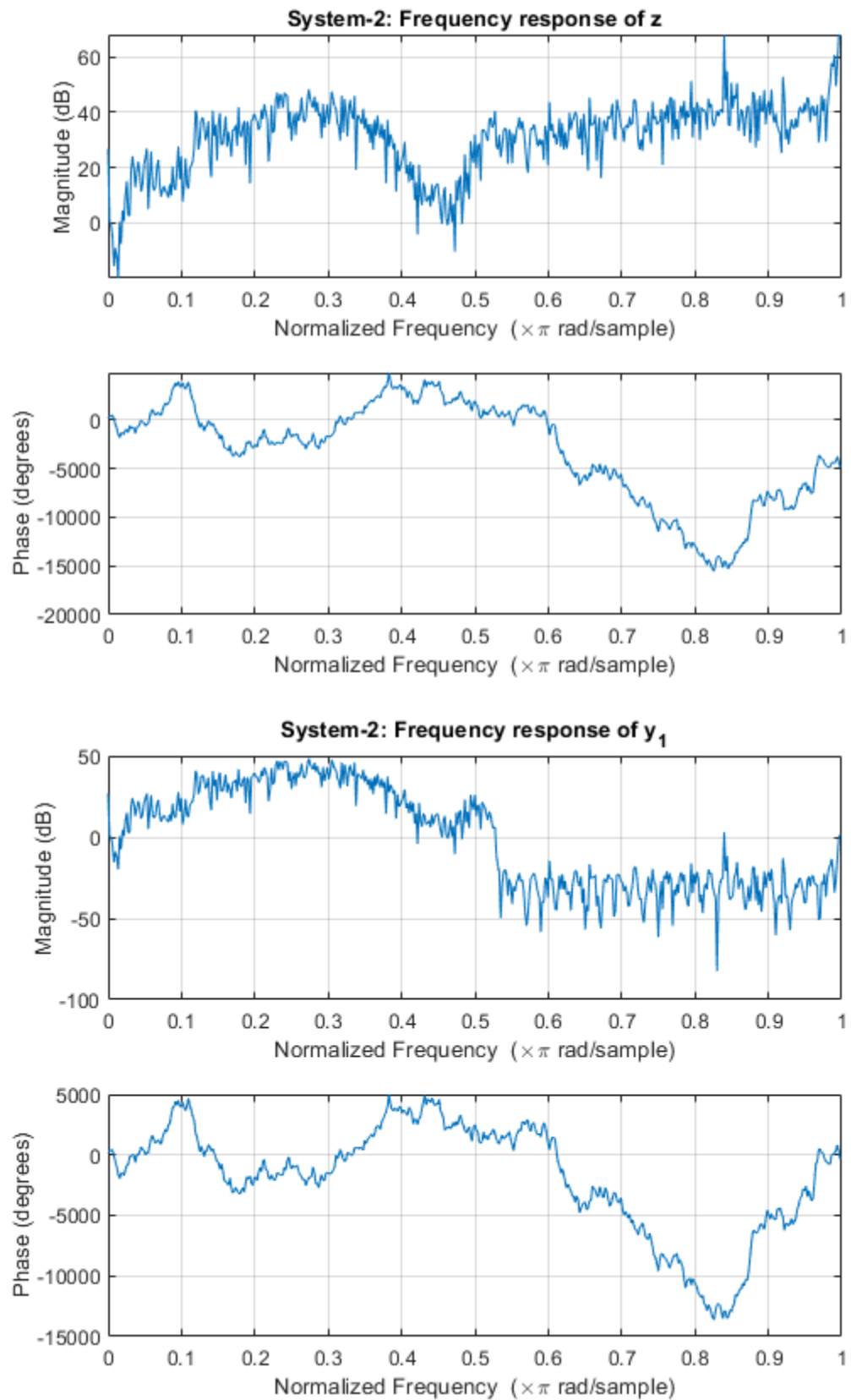
%Multiplying X2 with  $(-1)^n$ 
x22=zeros(len,1);
for k=1:length(x2_new)
    x22(k) =  $(-1)^{(k-1)}$  * x2_new(k);
end

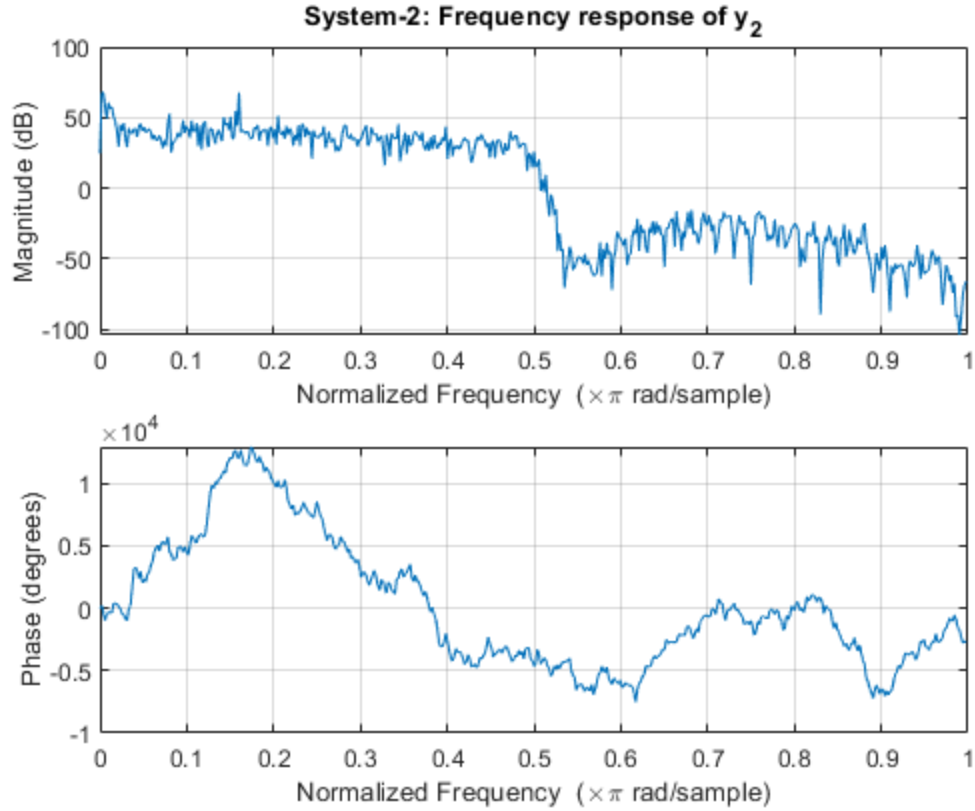
z=x1_new+x22;
figure
freqz(z)
title('System-2: Frequency response of z')

%Multiplying sum with  $(-1)^n$ 
z2=zeros(len,1);
for k=1:length(z)
    z2(k) =  $(-1)^{(k-1)}$  * z(k);
end
% Output signals
y1(:,1)=conv(h,z);
y2(:,1)=conv(h,z2);
figure
freqz(y1)
title('System-2: Frequency response of y_1')
figure
freqz(y2)
title('System-2: Frequency response of y_2')

%To listen
sound(z,Fs)
pause(30)
sound(y1,Fs)
pause(30)
sound(y2,Fs)
pause(30)
```







Observations

For System-1, the output z is the sum of x_1 and $x_2(-1)^n$. While you can hear the former in z , the multiplication by $(-1)^n$ turns x_2 to a high-frequency component, making it sound noisy. y_2 is almost the same as x_2 and y_1 has x_1 along with some noisy component from x_2 . This is because x_2 had a sound component in the high-frequency range (up to almost 0.85π). These when multiplied by $(-1)^n$ showed up in lower ranges and hence they were not fully filtered by the LPF H .

For System-2, the observations are similar for z and y_2 . Since the LPF H removed the high-frequency components of x_2 initially, the noisy effects of x_2 in y_1 is lesser in this case. However, the noise is not completely eliminated as H is just a 100 tap FIR filter (not the ideal LPF). Increasing the order would help to further reduce the noise.

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