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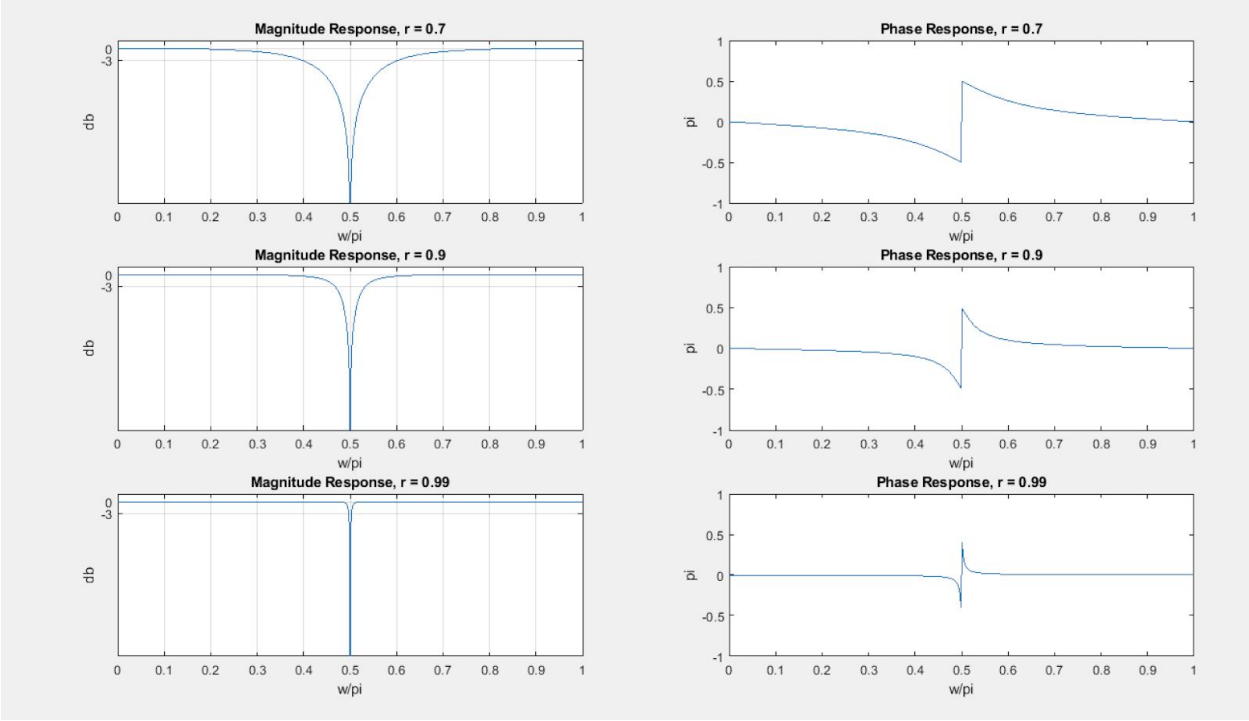
1.
r = 0.7
3db Bandwidth = 0.6597
r = 0.9
3db bandwidth = 0.2073
r = 0.99
3db bandwidth = 0.0188

```
% EE 442 HW 6 No1
omega0 = pi/2;
z1 = exp(j*omega0);
z2 = conj(z1);
b = poly([z1,z2]);
p1 = 0.7*exp(j*omega0);
p2 = conj(p1);
a = poly([p1,p2]);
o = pi*linspace(0,1,1001);
H0 = freqz(b,a,o);
MagH0 = abs(H0);
PhaH0 = angle(H0);
dbH0 = 20*log10(MagH0/max(MagH0));
dbH0(501) = -40;
figure;
subplot(3,2,1);
plot(o/pi,dbH0);
xlabel('w/pi');
ylabel('db');
title('Magnitude Response, r = 0.7');
xlim([0 1]);
ylim([-40 2]);
set(gca,'Ytick',[-3,0]);
grid;
subplot(3,2,2);
plot(o/pi, PhaH0/pi);
xlim([0 1]);
ylim([-1 1]);
xlabel('w/pi');
ylabel('pi');
title('Phase Response, r = 0.7');
p3 = 0.9*exp(j*omega0);
p4 = conj(p3);
a1 = poly([p3,p4]);
H1 = freqz(b,a1,o);
MagH1 = abs(H1);
PhaH1 = angle(H1);
dbH1 = 20*log10(MagH1/max(MagH1));
dbH1(501) = -40;
subplot(3,2,3);
plot(o/pi,dbH1);
xlabel('w/pi');
ylabel('db');
title('Magnitude Response, r = 0.9');
xlim([0 1]);
ylim([-40 2]);
set(gca,'Ytick',[-3,0]);
grid;
subplot(3,2,4);
plot(o/pi, PhaH1/pi);
xlim([0 1]);
ylim([-1 1]);
xlabel('w/pi');
ylabel('pi');
title('Phase Response, r = 0.9');
p5 = 0.99*exp(j*omega0);
p6 = conj(p5);
a2 = poly([p5,p6]);
H2 = freqz(b,a2,o);
MagH2 = abs(H2);
PhaH2 = angle(H2);
dbH2 = 20*log10(MagH2/max(MagH2));
dbH2(501) = -40;
subplot(3,2,5);
plot(o/pi,dbH2);
xlabel('w/pi');
ylabel('db');
title('Magnitude Response, r = 0.99');
xlim([0 1]);
ylim([-40 2]);
set(gca,'Ytick',[-3,0]);
grid;
subplot(3,2,6);
plot(o/pi, PhaH2/pi);
xlim([0 1]);
ylim([-1 1]);
xlabel('w/pi');
ylabel('pi');
```

```
title('Phase Response, r = 0.99');

%part2
%r = 0.7;
val0 = find(dbH0 <-3);
minVal0 = min(val0);
maxVal0 = max(val0);
computed0 = (maxVal0 - minVal0)*(pi/1000)

%r = 0.9;
val1 = find(dbH1 <-3);
minVal1 = min(val1);
maxVal1 = max(val1);
computed1 = (maxVal1 - minVal1)*(pi/1000)

%r = 0.99;
val2 = find(dbH2 <-3);
minVal2 = min(val2);
maxVal2 = max(val2);
computed2 = (maxVal2 - minVal2)*(pi/1000)
```

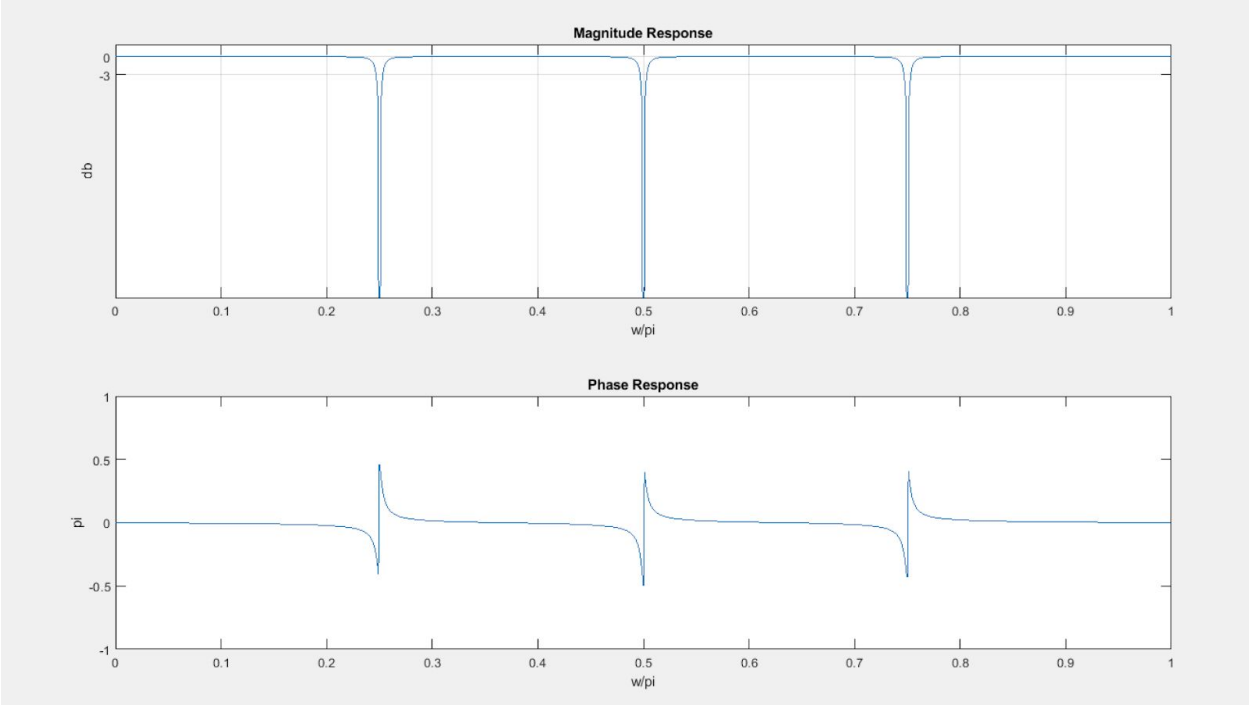
Plot



2. When adding the sines to the music, it will completely overtake the signal and the original signal is barely heard. After filtering, it seems the sound is much quieter but we can still hear it pretty clearly.

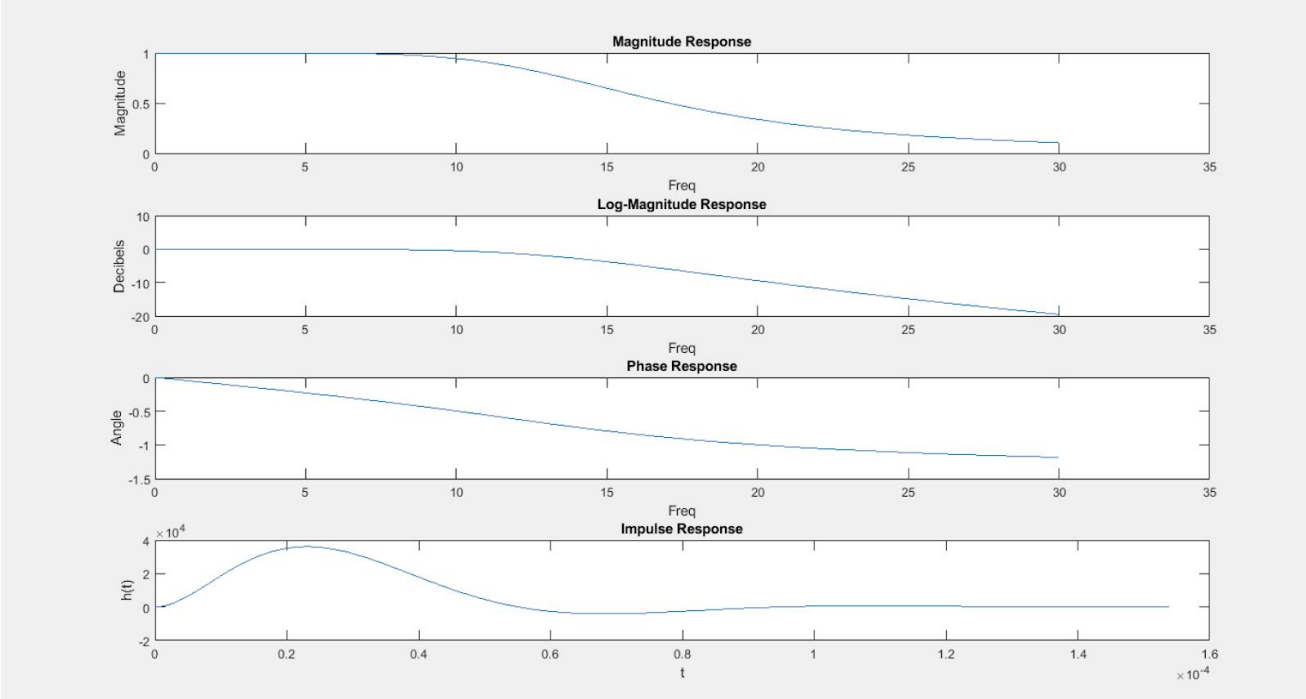
```
%Q2
fs = 8000;
omega0 = 2*pi*1000/8000;
omega1 = 2*pi*2000/8000;
omega2 = 2*pi*3000/8000;
z1 = exp(j*omega0);
z2 = conj(z1);
b1 = poly([z1,z2]);
p1 = 0.99*exp(j*omega0);
p2 = conj(p1);
a1 = poly([p1,p2]);
z3 = exp(j*omega1);
z4 = conj(z3);
b2 = poly([z3,z4]);
```

```
p3 = 0.99*exp(j*omega1);
p4 = conj(p3);
a2 = poly([p3,p4]);
z5 = exp(j*omega2);
z6 = conj(z5);
b3 = poly([z5,z6]);
p5 = 0.99*exp(j*omega2);
p6 = conj(p5);
a3 = poly([p5,p6]);
b = conv(b1,b2);
b = conv(b,b3);
a = conv(a1,a2);
a = conv(a,a3);

%Part 2

o = pi*linspace(0,1,1001);
H1 = freqz(b,a,o);
MagH1 = abs(H1);
PhaH1 = angle(H1);
dbH1 = 20*log10(MagH1/max(MagH1));
figure;
subplot(2,1,1);
plot(o/pi,dbH1);
xlabel('w/pi');
ylabel('db');
title('Magnitude Response');
xlim([0 1]);
ylim([-40 2]);
set(gca,'Ytick',[-3,0]);
grid;
subplot(2,1,2);
plot(o/pi, PhaH1/pi);
xlim([0 1]);
ylim([-1 1]);
xlabel('w/pi');
ylabel('pi');
title('Phase Response');
%%
%Part 3
load handel;
x = y';
nx = length(x);
n = 0:nx-1;
omega0 = 2*pi*1000/8000;
omega1 = 2*pi*2000/8000;
omega2 = 2*pi*3000/8000;
I0 = cos(omega0*n);
I1 = cos(omega1*n);
I2 = cos(omega2*n);
newX = x + I0 + I1 + I2;
sound(newX,Fs);
pause(5);
filtered = filter(b,a,newX);
sound(filtered, Fs);
```



3.

```
Wp = 2*pi*10000; Ws = 2*pi*20000; Rp = 0.5;
As = 9;
% Analog filter design:
[b,a] = afd_butt(Wp,Ws,Rp,As);
%*** Butterworth Filter Order = 9
% Calculation of second-order sections:
[C,B,A] = sdir2cas(b,a)
% Calculation of Frequency Response:
[db,mag,pha,w] = freqs_m(b,a,2*pi*30000);
pha = unwrap(pha);
% Calculation of Impulse response:
[ha,x,t] = impulse(b,a);

figure;
subplot(4,1,1);
plot(w/(2000*pi),mag);
title('Magnitude Response');
xlabel('Freq');
ylabel('Magnitude');
subplot(4,1,2);
plot(w/(2000*pi),db);
title('Log-Magnitude Response');
xlabel('Freq');
ylabel('Decibels');
subplot(4,1,3);
plot(w/(2000*pi),pha/pi);
xlabel('Freq');
ylabel('Angle');
title('Phase Response');
subplot(4,1,4);
plot(t,ha);
title('Impulse Response');
xlabel('t');
ylabel('h(t)');
```



4.

```
%EE 442

Wp = 10; Ws = 15; Rp = 1; As = 50;

% Analog filter design:
[b,a] = afd_chb1(Wp,Ws,Rp,As);
% Calculation of second-order sections:
```

```
[C,B,A] = sdir2cas(b,a)
a0 = a(1);
b=b/a0;
a=a/a0;
% Calculation of Frequency Response:
[db,mag,pha,w] = freqs_m(b,a,30);
pha = unwrap(pha);
 % Calculation of Impulse response:
 [ha,x,t] = impulse(b,a);

 figure;
subplot(4,1,1);
plot(w,mag);
title('Magnitude Response');
xlabel('Freq');
ylabel('Magnitude');
subplot(4,1,2);
plot(w,db);
title('Log-Magnitude Response');
xlabel('Freq');
ylabel('Decibels');
subplot(4,1,3);
plot(w,pha/pi);
xlabel('Freq');
ylabel('Angle');
title('Phase Response');
subplot(4,1,4);
plot(t,ha);
title('Impulse Response');
xlabel('t');
ylabel('h(t)');
```