EE 387 – SIGNAL PROCESSING
Lab 3 - SYSTEM FUNCTIONS AND FREQUENCY RESPONSE

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Part 01

Using the method given above, find out the zeros and poles of the following system functions and plot them:

1. $H(s) = \frac{s+5}{s^2+2s+3}$

2. $H(s) = \frac{2s^2+5s+12}{s^2+2s+10}$

3. $H(s) = \frac{2s^2+5s+12}{(s^2+2s+10)(s+2)}$

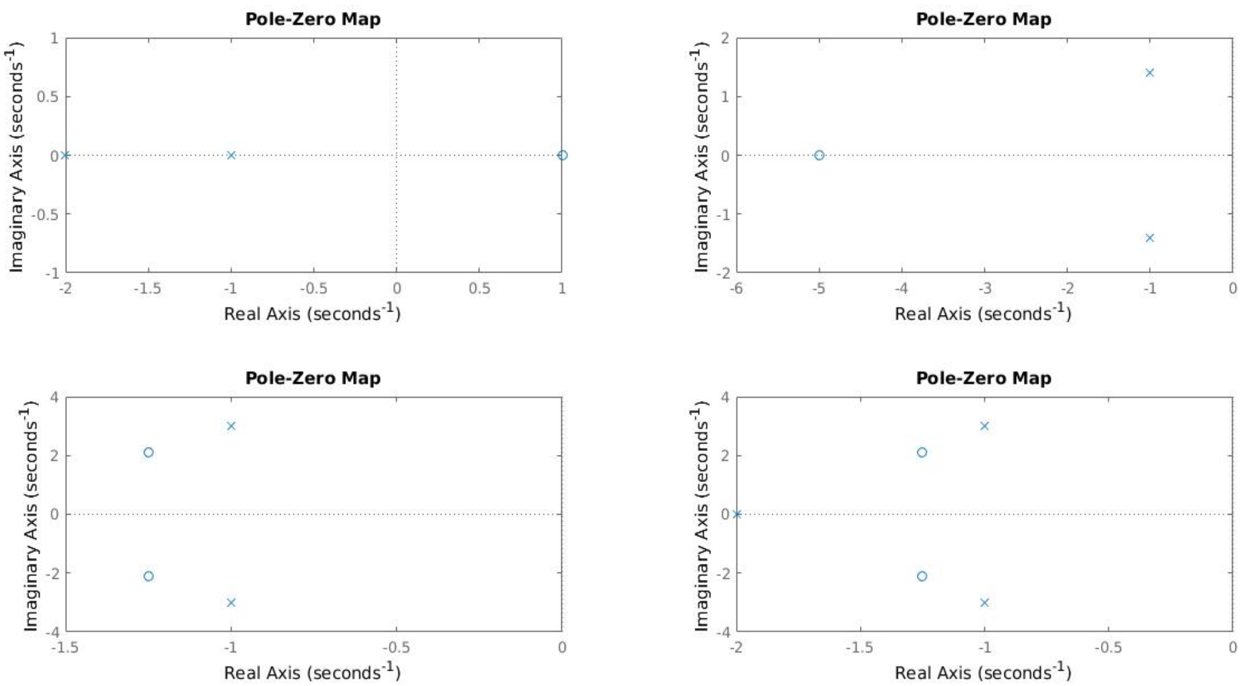
part01.m

```
clear all;
close all;
subplot(2,2,1)
b = [1 -1]; % Numerator coefficients
a = [1 3 2]; % Demoninator coefficients
zs = roots(b); % Generetes Zeros
ps = roots(a); % Generetes poles
pzmap(ps,zs); % generates pole-zero diagram


n1=[1,5];
d1=[1,2,3];
zeros1=roots(n1);
poles1=roots(d1);
subplot(2,2,2);
pzmap(poles1,zeros1);


n2=[2,5,12];
d2=[1,2,10];
zeros2=roots(n2);
poles2=roots(d2);
subplot(2,2,3);
pzmap(poles2,zeros2);

n3=[2,5,12];
d3=conv([1,2,10],[1,2]);
zeros3=roots(n3);
poles3=roots(d3);
subplot(2,2,4);
pzmap(poles3,zeros3);
```



Part 02

Consider a system function:

$$H(s) = \frac{2s^2 + 2s + 17}{s^2 + 4s + 104}$$

1. Define the numerator and denominator polynomial coefficients as vector b and a respectively.

2. Use the *freqs* function to evaluate the frequency response of a Laplace transform.

```
H = freqs(b,a,omega);
```

   where $-20 \leq \omega \leq 20$ (ω) is the frequency vector in rad/s. (Hint: use *linspace* to generate a vector with 200 samples.)

3. Plot the magnitude and phase of the frequency response.

4. Plot the bode plot of the given $H(S)$ by utilizing the results in 2. (Hint: use the definitions of the bode plot)

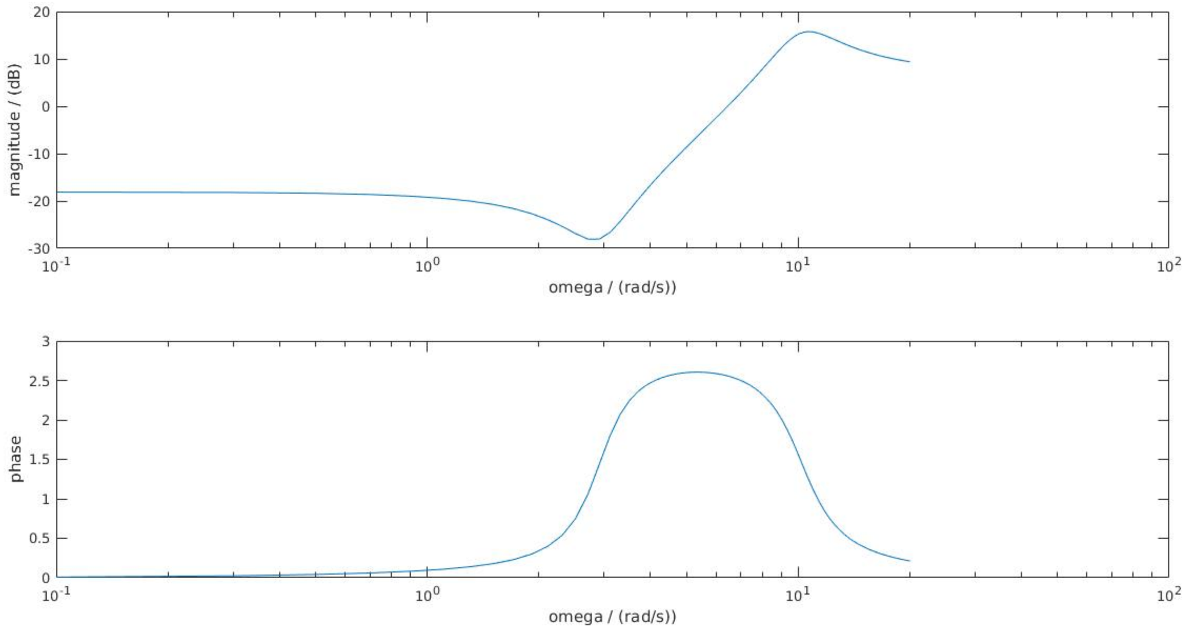
part02.m

```
b=[2,2,17];
a=[1,4,104];
omega=linspace(-20,20,200);
H=freqs(b,a,omega);
subplot(2,1,1);
plot(omega,abs(H))
xlabel('omega / (rad/s))');
ylabel('magnitude of response');
subplot(2,1,2);
```

```
plot(omega,phase(H))
xlabel('omega / (rad/s))');
ylabel('phase of response');

figure;
subplot(2,1,1)
semilogx(omega,10*log(abs(H)));
xlabel('omega / (rad/s))');
ylabel('magnitude / (dB)');

subplot(2,1,2)
semilogx(omega,phase(H));
xlabel('omega / (rad/s))');
ylabel('phase');
```



Exercise

1. Plot the bode plot of each four system functions given in the part 1.

2. Select three sinusoidal signals with unit magnitude, zero phase and three different frequencies (f_1, f_2, f_3 *in kHz*, here $f_i = Registration\ number * i$). Assume that they are three inputs for abovementioned four systems. Then find the corresponding three outputs for each system.

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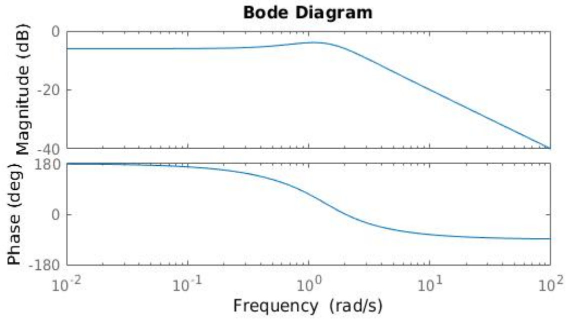
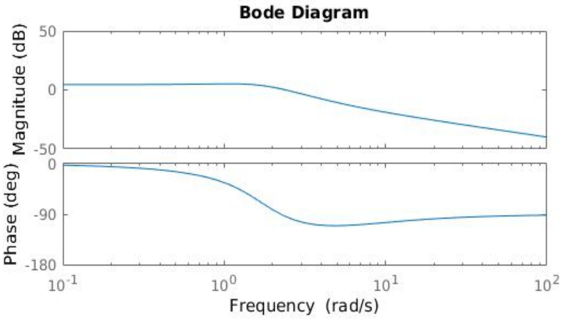
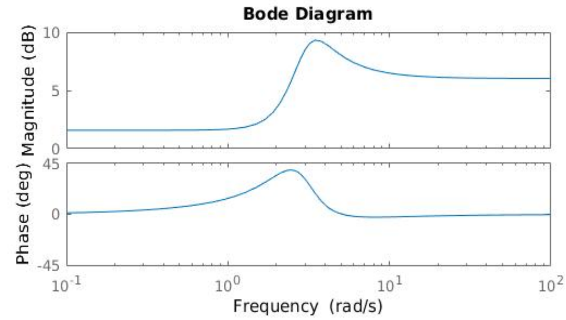
part02exercise.m

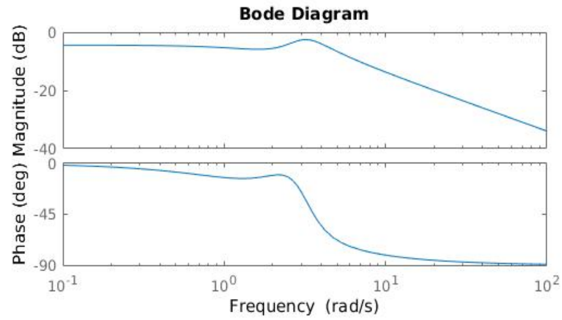
```
close all
clear all
figure

subplot(2,2,1);
n1=[1,-1];
d1=[1,2,2];
sys1=tf(n1,d1);bode(sys1);

subplot(2,2,2);
n2=[1,5];
d2=[1,2,3];
sys2=tf(n2,d2);
bode(sys2);

subplot(2,2,3);
n3=[2,5,12];
d3=[1,2,10];
sys3=tf(n3,d3);
bode(sys3);

subplot(2,2,4)
n4=[2,5,12];
d4=conv([1,2,10],[1,2]);
sys4=tf(n4,d4);
bode(sys4);


for ii=1:3
   figure
   fi=158*ii;
   t=linspace(0,0.002*pi,20);
   x=sin(2*pi*fi*t);

   subplot(4,1,1);
   sys1=tf(n1,d1,fi);
   [y1,t1]=lsim(sys1,x);
   plot(t1,y1);

   subplot(4,1,2);
   sys2=tf(n2,d2,fi);
   [y2,t2]=lsim(sys2,x);
   plot(t2,y2);

   subplot(4,1,3);
   sys3=tf(n3,d3,fi);
   [y3,t3]=lsim(sys3,x);
   plot(t3,y3);

   subplot(4,1,4);
```

```
    sys4=tf(n4,d4,fi);
    [y4,t4]=lsim(sys4,x);
    plot(t4,y4);

end
```

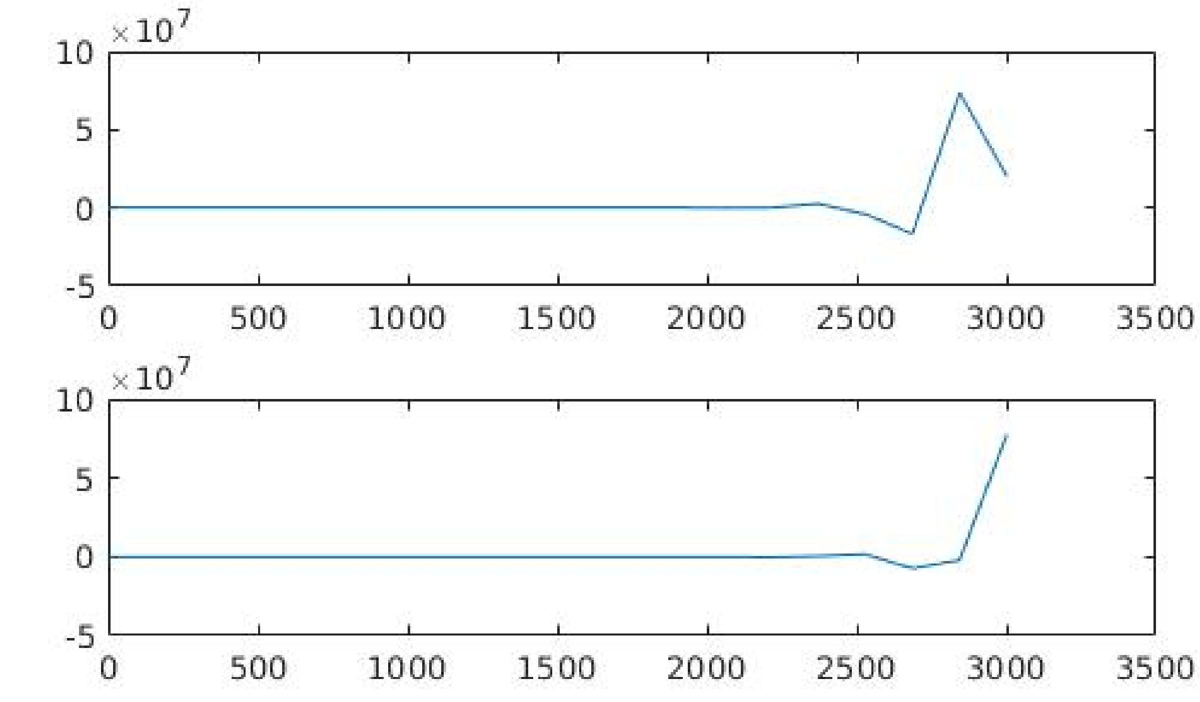




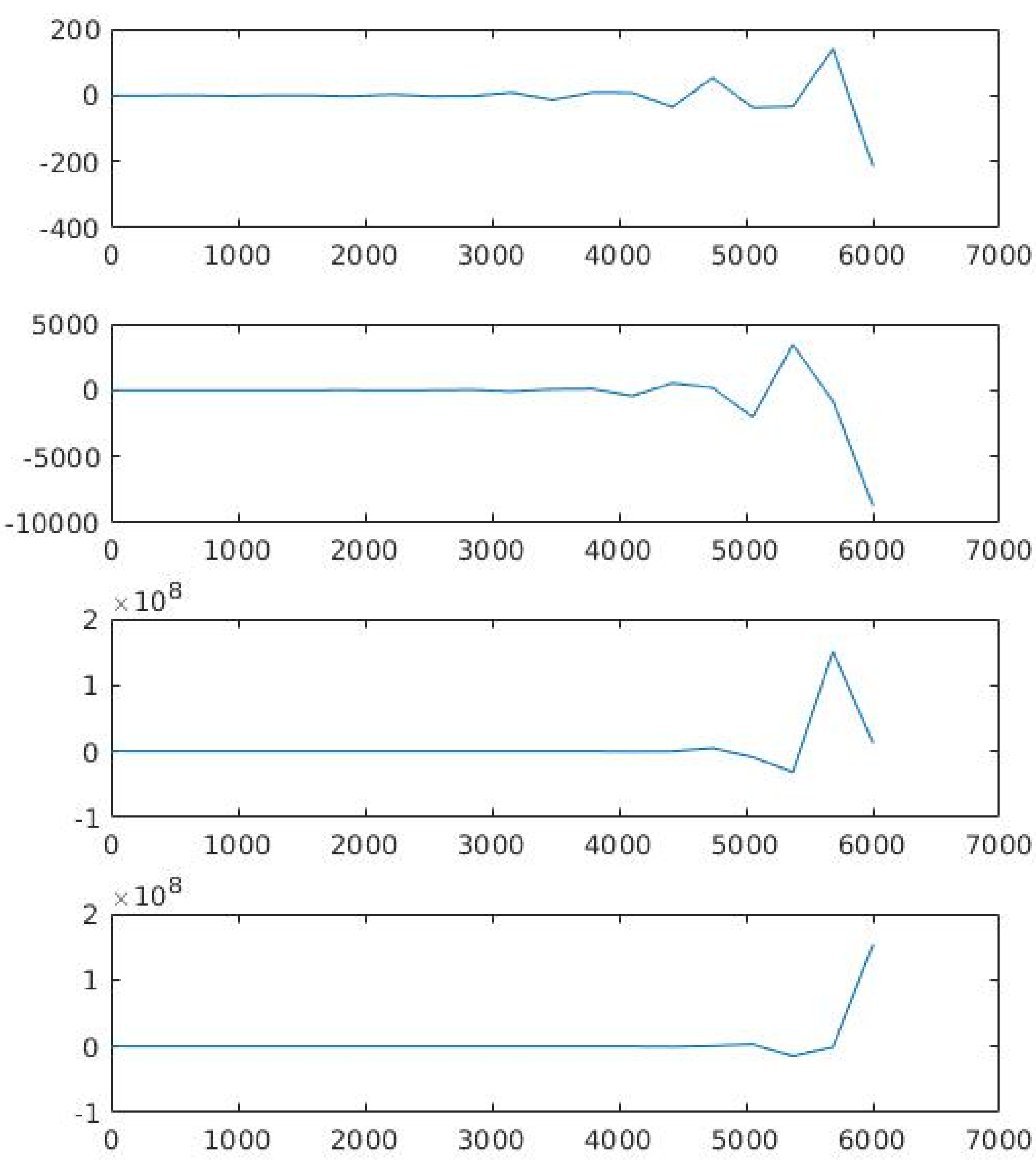




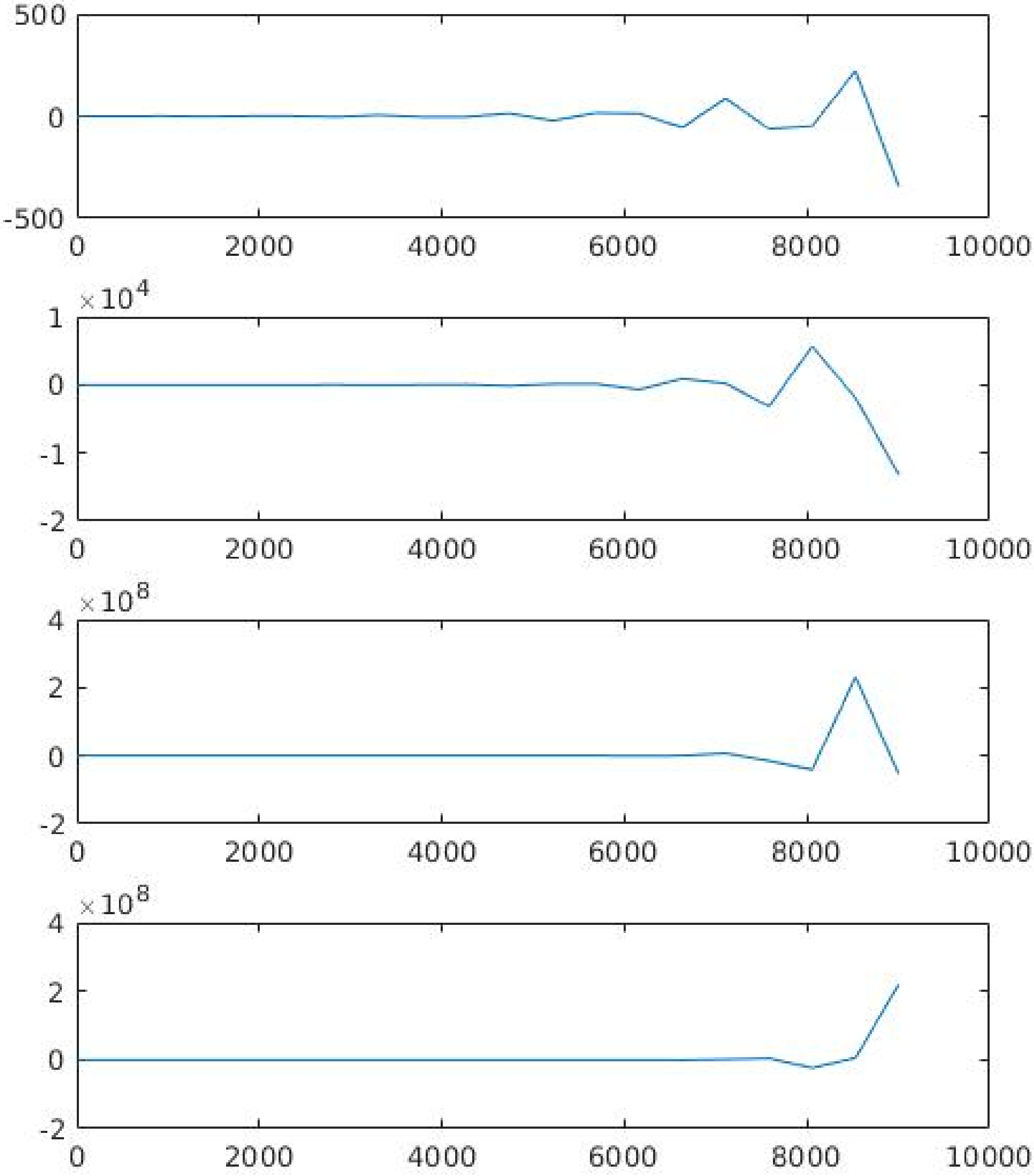
f= 158Hz
x(t)=sin(2*pi*158)



f=158*2Hz
x(t)=sin(2*pi*316)



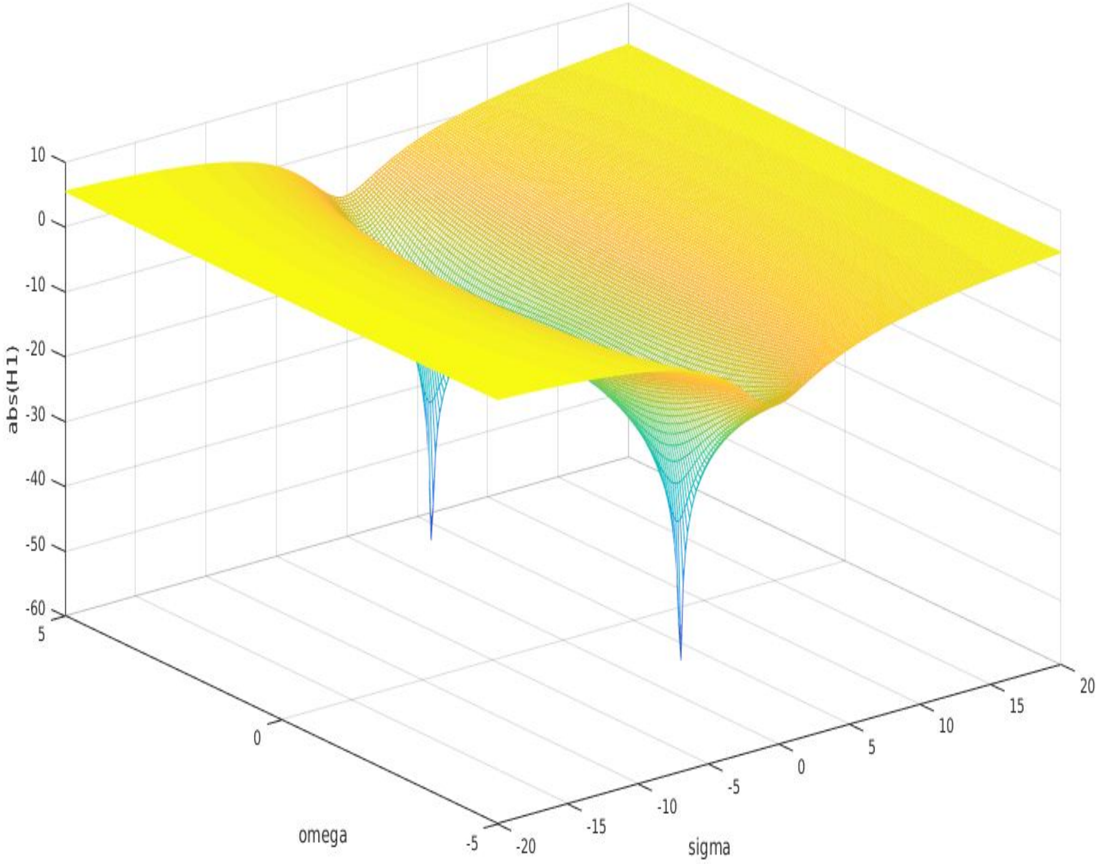
f=158*3Hz
x(t)=sin(2*pi*474)



Part 03

part03.m

```
clear all;
close all;

sigma = linspace(-20, 20, 200);
omega = linspace(-5, 5, 200);
[sigmagrid, omegagrid] = meshgrid(sigma, omega);
sgrid = sigmagrid + 1i*omegagrid;

b = [2 2 17];
a = [1 4 104];
H1 = polyval(b, sgrid)./polyval(a, sgrid);
mesh(sigma, omega, 20*log10(abs(H1)));
xlabel('sigma');
ylabel('omega');
zlabel('abs(H1)');
```



Where are the poles and zeros on the surface plot? What's the relationship between the surface plot and the plot in 2.(2) ?

2.2 is the sigma=0 cross section of this plot. (in logarithmic scale)