EE387 – Signal Processing

Lab03 - System Functions and Frequency Response

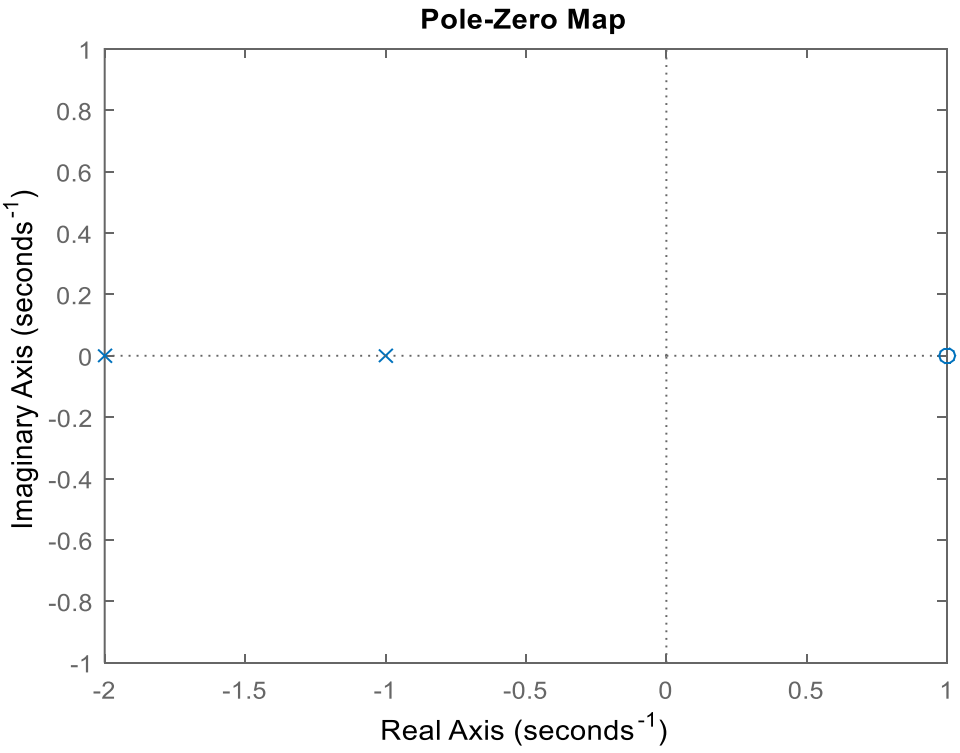
E/14/017

PART 1: Pole-Zero Diagrams in MATLAB.

Example

Code is included as code -> **example.m**

```
clear all;
close all;
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
```



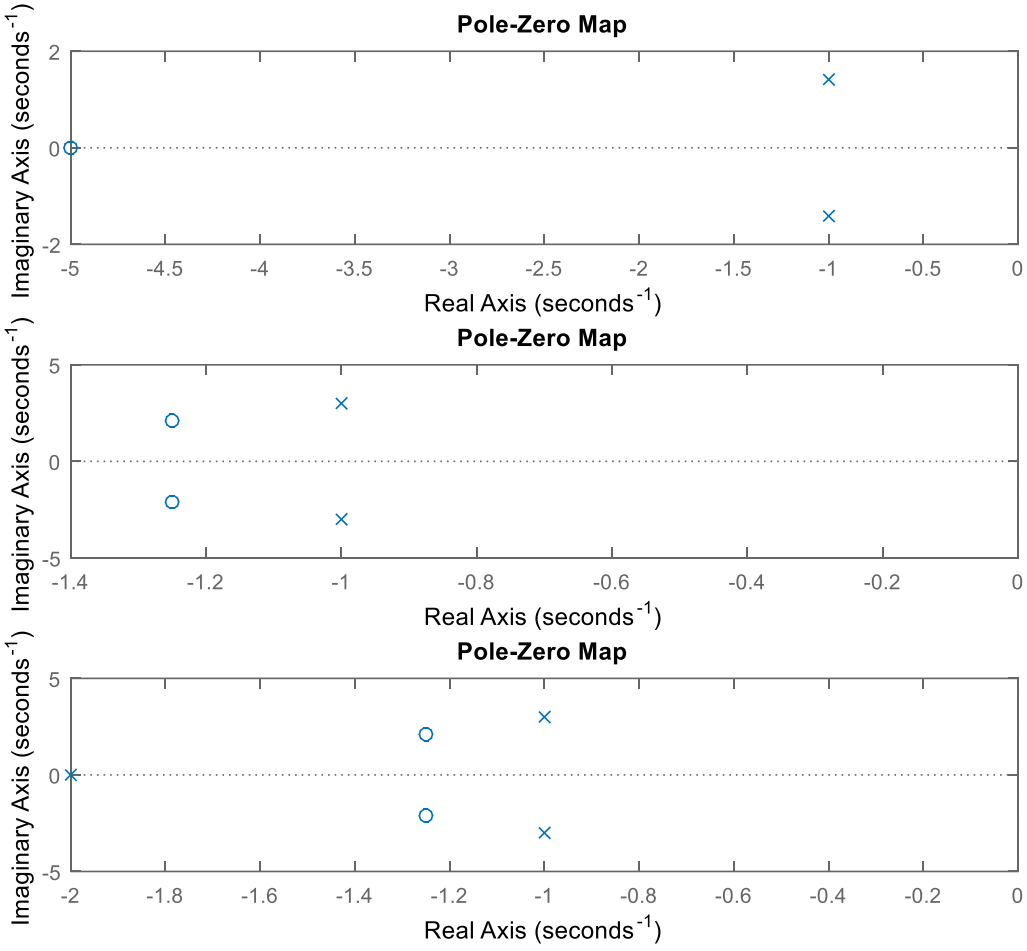
Exercise

Code is included as Code -> **part1.m**

```
a1 = [1 5];
b1 = [1 2 3];
z1 = roots(a1);
p1 = roots(b1);
subplot(3,1,1);
pzmap(p1,z1);

a2 = [2 5 12];
b2 = [1 2 10];
z2 = roots(a2);
p2 = roots(b2);
subplot(3,1,2);
pzmap(p2,z2);

a3 = [2 5 12];
b3 = [1 4 14 20];
z3 = roots(a3);
p3 = roots(b3);
subplot(3,1,3);
pzmap(p3,z3);
```



PART 2: Frequency Response and Bode Plots in MATLAB

Code is included as Code -> **part1.m**

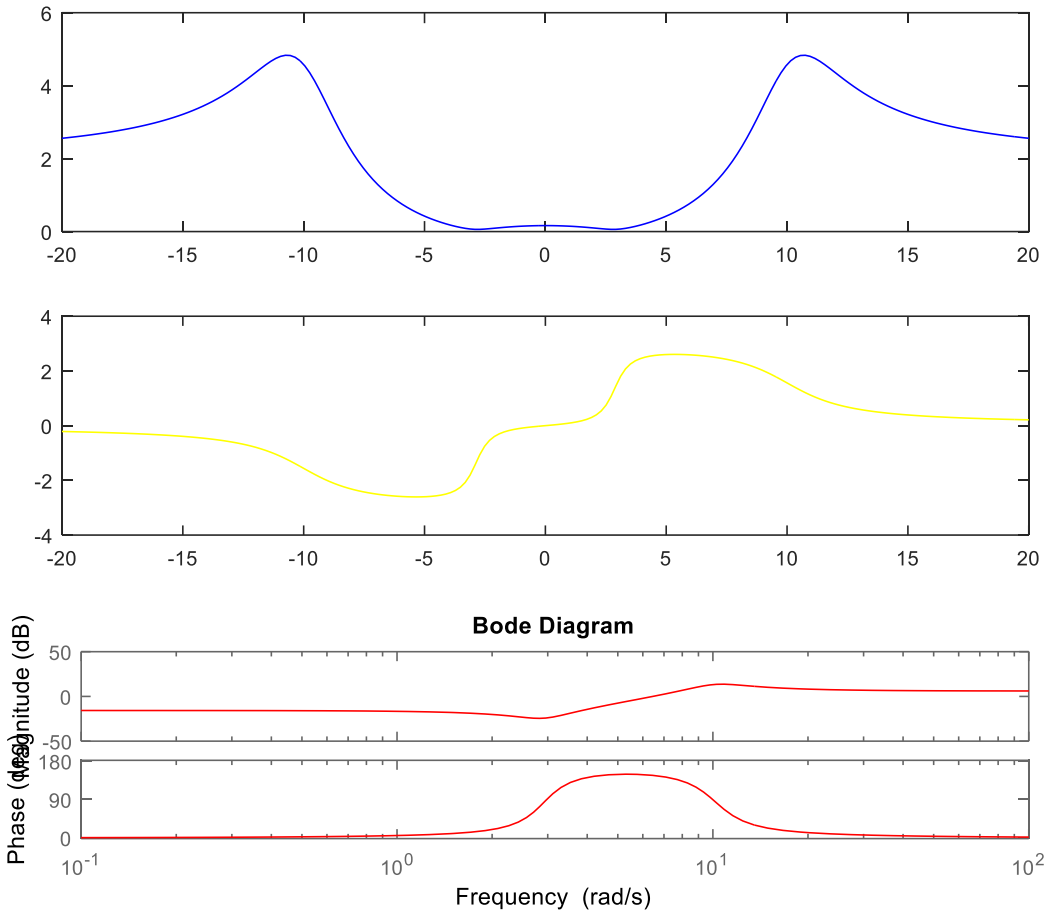
```
a = [2 2 17];
b = [1 4 104];
o = linspace(-20,20,200);

x = freqs(a,b,o);
subplot(3,1,1);
plot(o, abs(x),'b');

subplot(3,1,2)
plot(o, angle(x),'y');

x1=tf(a,b);
```

```
subplot(3,1,3)
bode(x1,'r');
```



Exercise

Code is included as Code -> **part2_ex1.m**

```
a1 = [1 -1];
b1 = [1 3 2];

a2 = [1 5];
b2 = [1 2 3];

a3 = [2 5 12];
b3 = [1 2 10];

a4 = [2 5 12];
```

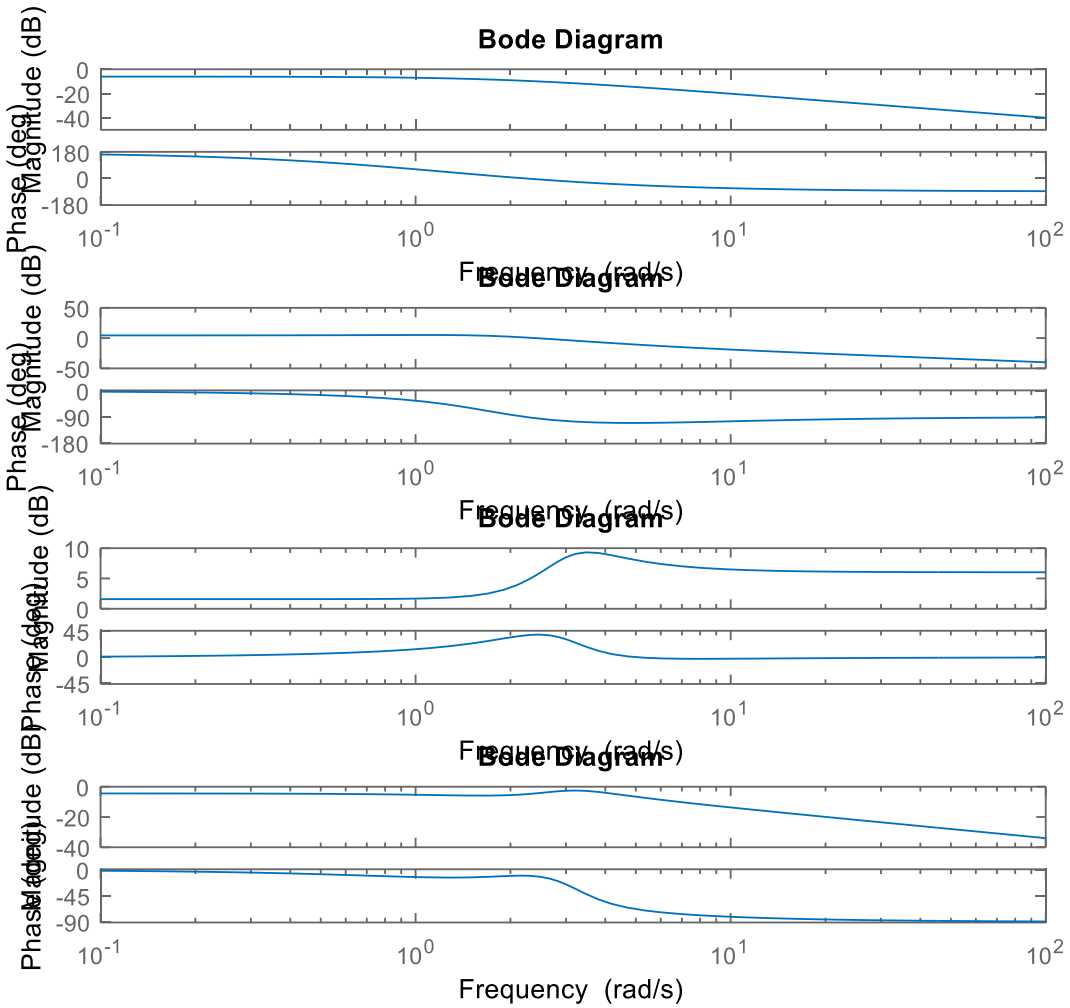
```
b4 = [1 4 14 20];

x1=tf(a1,b1);
subplot(4,1,1)
bode(x1);

x2=tf(a2,b2);
subplot(4,1,2)
bode(x2);

x3=tf(a3,b3);
subplot(4,1,3)
bode(x3);

x4=tf(a4,b4);
subplot(4,1,4)
bode(x4);
```



Code is included as Code -> **part2_ex2.m**

```
syms s;
t = linspace(-20,20,200);

lh1 = (s-1)./(s*s+2*s+2);
lh2 = (s+5)./(s*s+2*s+3);
lh3 = (2*s*s+5*s+12)./(s*s+2*s+10);
lh4 = (2*s*s+5*s+12)./(s.^3+4*s*s+14*s+20);

w1 = 2*pi*17*1;
w2 = 2*pi*17*2;
w3 = 2*pi*17*3;

x1 = sin(w1*t);
```

```
x2 = sin(w2*t);
x3 = sin(w3*t);

%give signal x1 to all the systems
ly11 = lx1.*lh1;
y11 = ilaplace(ly11)

ly12 = lx1.*lh2;
y12 = ilaplace(ly12)

ly13 = lx1.*lh3;
y13 = ilaplace(ly13)

ly14 = lx1.*lh4;
y14 = ilaplace(ly14)

%give signal x2 to all the systems
ly21 = lx2.*lh1;
y21 = ilaplace(ly21)

ly22 = lx2.*lh2;
y22 = ilaplace(ly22)

ly23 = lx2.*lh3;
y23 = ilaplace(ly23)

ly24 = lx2.*lh4;
y24 = ilaplace(ly24)

%give signal x3 to all the systems
ly31 = lx3.*lh1;
y31 = ilaplace(ly31)

ly32 = lx3.*lh2;
y32 = ilaplace(ly32)

ly33 = lx3.*lh3;
y33 = ilaplace(ly33)

ly34 = lx3.*lh4;
y34 = ilaplace(ly34)
```

Output

```
>> part2_ex2

y11 =

- (sin(34*pi*t)/2 - 34*pi*cos(34*pi*t) + 9826*pi^3*cos(34*pi*t) - 867*pi^2*sin(34*pi*t))/((578*pi^2 - 34*pi + 1)*(34*pi + 578*pi^2 + 1)) - (exp(-t)*(34*pi - 9826*pi^3)*(cos(t) + sin(t)*((51*pi + 9826*pi^3)/(34*pi - 9826*pi^3) - 1)))/((578*pi^2 - 34*pi + 1)*(34*pi + 578*pi^2 + 1))


y12 =

(exp(-t)*(238*pi + 39304*pi^3)*(cos(2^(1/2)*t) - (2^(1/2)*sin(2^(1/2)*t)*((34*pi - 196520*pi^3)/(238*pi + 39304*pi^3) + 1))/2))/(1336336*pi^4 - 2312*pi^2 + 9) - (238*pi*cos(34*pi*t) - 15*sin(34*pi*t) + 39304*pi^3*cos(34*pi*t) + 3468*pi^2*sin(34*pi*t))/(1336336*pi^4 - 2312*pi^2 + 9)


y13 =

(30*sin(34*pi*t) + 221*pi*cos(34*pi*t) - 9826*pi^3*cos(34*pi*t) - 6358*pi^2*sin(34*pi*t) + 668168*pi^4*sin(34*pi*t))/((578*pi^2 - 102*pi + 5)*(102*pi + 578*pi^2 + 5)) - (exp(-t)*(221*pi - 9826*pi^3)*(cos(3*t) - sin(3*t)*((238*pi - 78608*pi^3)/(3*(221*pi - 9826*pi^3)) + 1/3)))/((578*pi^2 - 102*pi + 5)*(102*pi + 578*pi^2 + 5))


y14 =

(17*pi*exp(-2*t))/(578*pi^2 + 2) + (30*sin(34*pi*t) - 289*pi*cos(34*pi*t) + 98260*pi^3*cos(34*pi*t) - 11358856*pi^5*cos(34*pi*t) - 2601*pi^2*sin(34*pi*t) + 501126*pi^4*sin(34*pi*t))/((578*pi^2 + 2)*(578*pi^2 - 102*pi + 5)*(102*pi + 578*pi^2 + 5)) - (exp(-t)*(68*pi - 9826*pi^3)*(cos(3*t) + sin(3*t)*((221*pi - 9826*pi^3)/(3*(68*pi - 9826*pi^3)) - 1/3)))/((578*pi^2 - 102*pi + 5)*(102*pi + 578*pi^2 + 5))
```

y21 =

- (sin(68*pi*t)/2 - 68*pi*cos(68*pi*t) + 78608*pi^3*cos(68*pi*t) - 3468*pi^2*sin(68*pi*t))/((2312*pi^2 - 68*pi + 1)*(68*pi + 2312*pi^2 + 1)) - (exp(-t)*(68*pi - 78608*pi^3)*(cos(t) + sin(t)*((102*pi + 78608*pi^3)/(68*pi - 78608*pi^3) - 1)))/((2312*pi^2 - 68*pi + 1)*(68*pi + 2312*pi^2 + 1))

y22 =

(exp(-t)*(476*pi + 314432*pi^3)*(cos(2^(1/2)*t) - (2^(1/2)*sin(2^(1/2)*t)*((68*pi - 1572160*pi^3)/(476*pi + 314432*pi^3) + 1))/2))/(21381376*pi^4 - 9248*pi^2 + 9) - (476*pi*cos(68*pi*t) - 15*sin(68*pi*t) + 314432*pi^3*cos(68*pi*t) + 13872*pi^2*sin(68*pi*t))/(21381376*pi^4 - 9248*pi^2 + 9)

y23 =

(30*sin(68*pi*t) + 442*pi*cos(68*pi*t) - 78608*pi^3*cos(68*pi*t) - 25432*pi^2*sin(68*pi*t) + 10690688*pi^4*sin(68*pi*t))/((2312*pi^2 - 204*pi + 5)*(204*pi + 2312*pi^2 + 5)) - (exp(-t)*(442*pi - 78608*pi^3)*(cos(3*t) - sin(3*t)*((476*pi - 628864*pi^3)/(3*(442*pi - 78608*pi^3)) + 1/3)))/((2312*pi^2 - 204*pi + 5)*(204*pi + 2312*pi^2 + 5))

y24 =

(17*pi*exp(-2*t))/(1156*pi^2 + 1) + (15*sin(68*pi*t) - 289*pi*cos(68*pi*t) + 393040*pi^3*cos(68*pi*t) - 181741696*pi^5*cos(68*pi*t) - 5202*pi^2*sin(68*pi*t) + 4009008*pi^4*sin(68*pi*t))/((1156*pi^2 + 1)*(2312*pi^2 - 204*pi + 5)*(204*pi + 2312*pi^2 + 5)) - (exp(-t)*(136*pi - 78608*pi^3)*(cos(3*t) + sin(3*t)*((442*pi - 78608*pi^3)/(3*(136*pi - 78608*pi^3)) - 1/3)))/((2312*pi^2 - 204*pi + 5)*(204*pi + 2312*pi^2 + 5))

y31 =

- (sin(102*pi*t)/2 - 102*pi*cos(102*pi*t) + 265302*pi^3*cos(102*pi*t) - 7803*pi^2*sin(102*pi*t))/((5202*pi^2 - 102*pi + 1)*(102*pi + 5202*pi^2 + 1)) - (exp(-t)*(102*pi - 265302*pi^3)*(cos(t) + sin(t)*((153*pi + 265302*pi^3)/(102*pi - 265302*pi^3) - 1)))/((5202*pi^2 - 102*pi + 1)*(102*pi + 5202*pi^2 + 1))

y32 =

(exp(-t)*(238*pi + 353736*pi^3)*(cos(2^(1/2)*t) - (2^(1/2)*sin(2^(1/2)*t)*((34*pi - 1768680*pi^3)/(238*pi + 353736*pi^3) + 1))/2))/(36081072*pi^4 - 6936*pi^2 + 3) - (238*pi*cos(102*pi*t) - 5*sin(102*pi*t) + 353736*pi^3*cos(102*pi*t) + 10404*pi^2*sin(102*pi*t))/(36081072*pi^4 - 6936*pi^2 + 3)

y33 =

(30*sin(102*pi*t) + 663*pi*cos(102*pi*t) - 265302*pi^3*cos(102*pi*t) - 57222*pi^2*sin(102*pi*t) + 54121608*pi^4*sin(102*pi*t))/((5202*pi^2 - 306*pi + 5)*(306*pi + 5202*pi^2 + 5)) - (exp(-t)*(663*pi - 265302*pi^3)*(cos(3*t) - sin(3*t)*((714*pi - 2122416*pi^3)/(3*(663*pi - 265302*pi^3)) + 1/3)))/((5202*pi^2 - 306*pi + 5)*(306*pi + 5202*pi^2 + 5))

y34 =

(51*pi*exp(-2*t))/(5202*pi^2 + 2) + (30*sin(102*pi*t) - 867*pi*cos(102*pi*t) + 2653020*pi^3*cos(102*pi*t) - 2760202008*pi^5*cos(102*pi*t) - 23409*pi^2*sin(102*pi*t) + 40591206*pi^4*sin(102*pi*t))/((5202*pi^2 + 2)*(5202*pi^2 - 306*pi + 5)*(306*pi + 5202*pi^2 + 5)) - (exp(-t)*(204*pi - 265302*pi^3)*(cos(3*t) + sin(3*t)*((663*pi - 265302*pi^3)/(3*(204*pi - 265302*pi^3)) - 1/3)))/((5202*pi^2 - 306*pi + 5)*(306*pi + 5202*pi^2 + 5))

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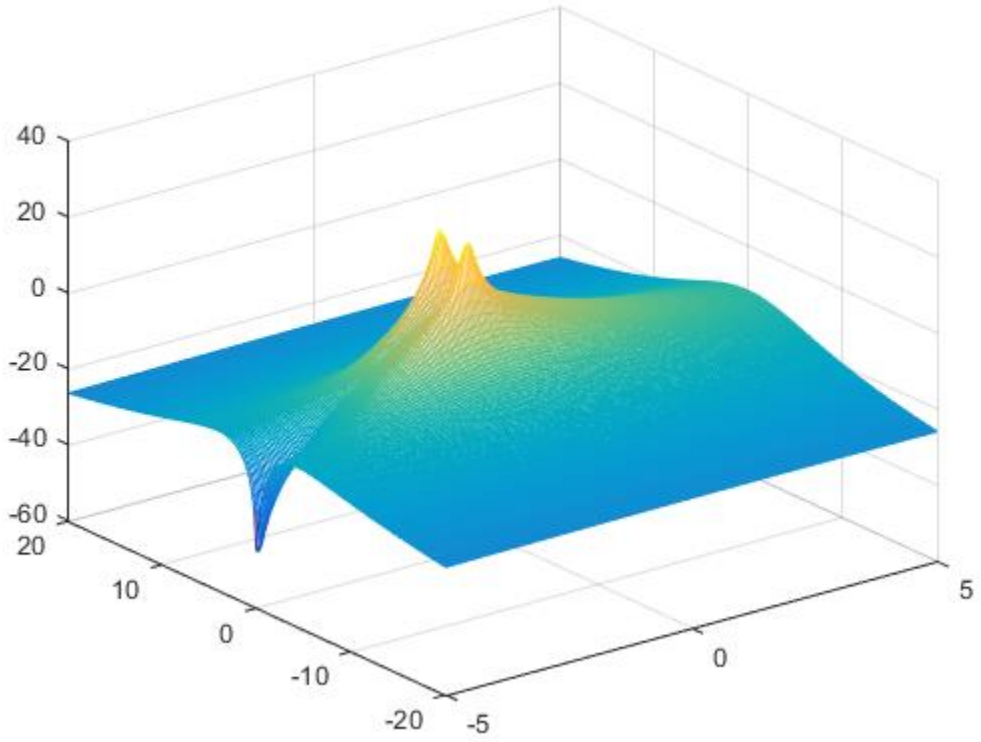
PART 3: Surface Plots of a System Function in MATLAB

Code is included as Code -> **part3.m**



Zeros and poles are in the XY horizontal plane. Poles are same in two bode plot and the surface plot.