System Functions and Frequency Response

KUMARASIRI G.M.D

E/13/200

SEMESTER 06

Title: **Lab03: System Functions and Frequency Response**

Date: **2017-09-30**

Objectives: **1.** Learn MATLAB basics to use the system functions

2. Use MATLAB to determine the frequency response of a given LTI system

PART 1: Pole-Zero Diagrams in MATLAB

By using the 'pzmap' command in MATLAB it can be plot the poles and zeros for following frequency responses.

1. H(s) = (s+5)/(s²+2s+3)

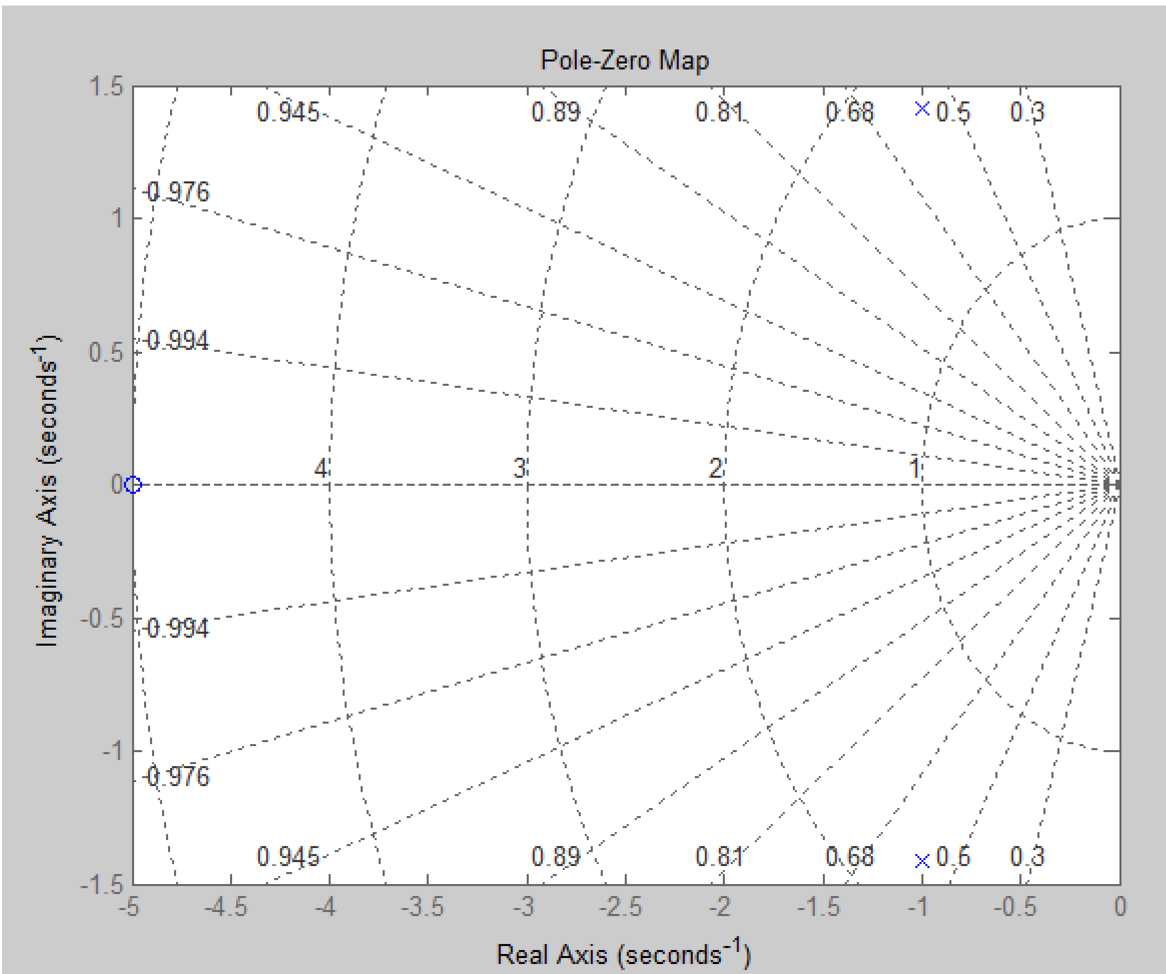

Figure 01

2. H(s) = (2s²+5s+12)/(s²+2s+10)

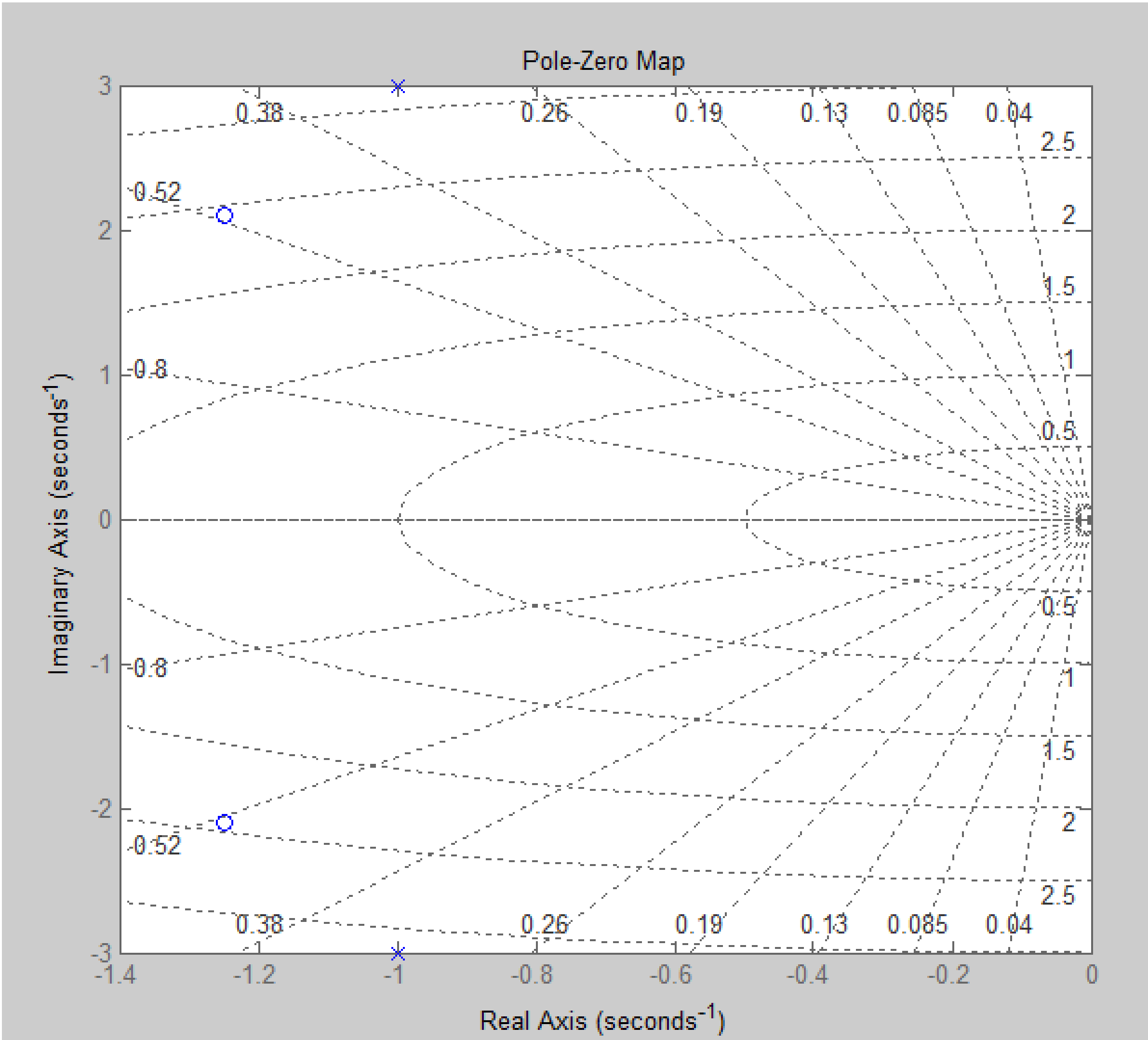

Figure 02

3. $H(s) = (2s^2+5s+12)/(s^2+2s+10)(s+2)$

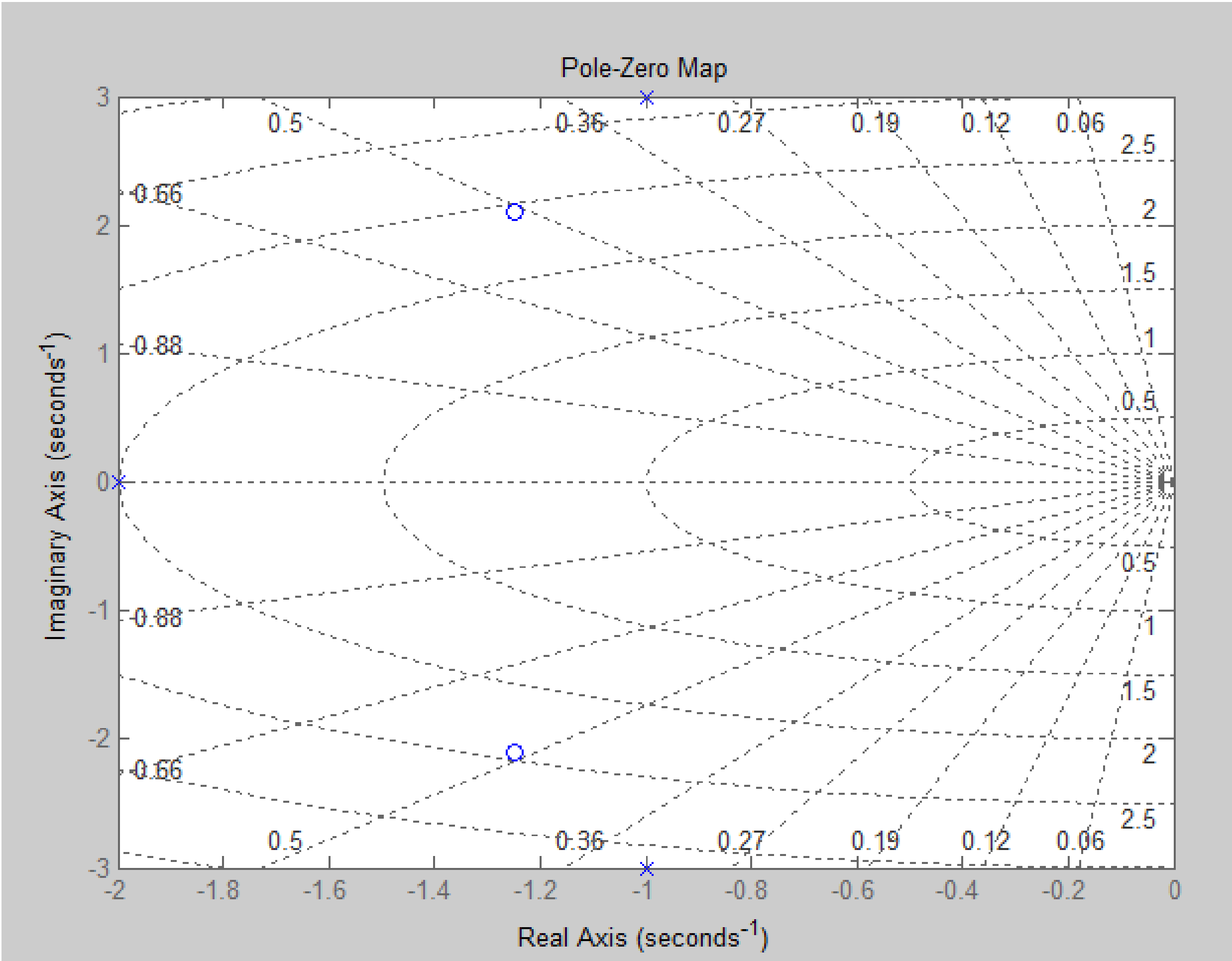

Figure 03

PART 2: Frequency Response and Bode Plots in MATLAB

For complete this part the following frequency response function has used.

$$H(s) = (2s^2+2s+17)/(s^2+4s+104)$$

Here it can be used the 'freqs' MATLAB command to evaluate the H values for given omega values. For evaluating the H, the omega has selected as a vector with selected range ($-20 \leq$ omega ≤ 20, for 200 samples)

Here are the plots for magnitude and the phase for all frequency responses over specified omega range.

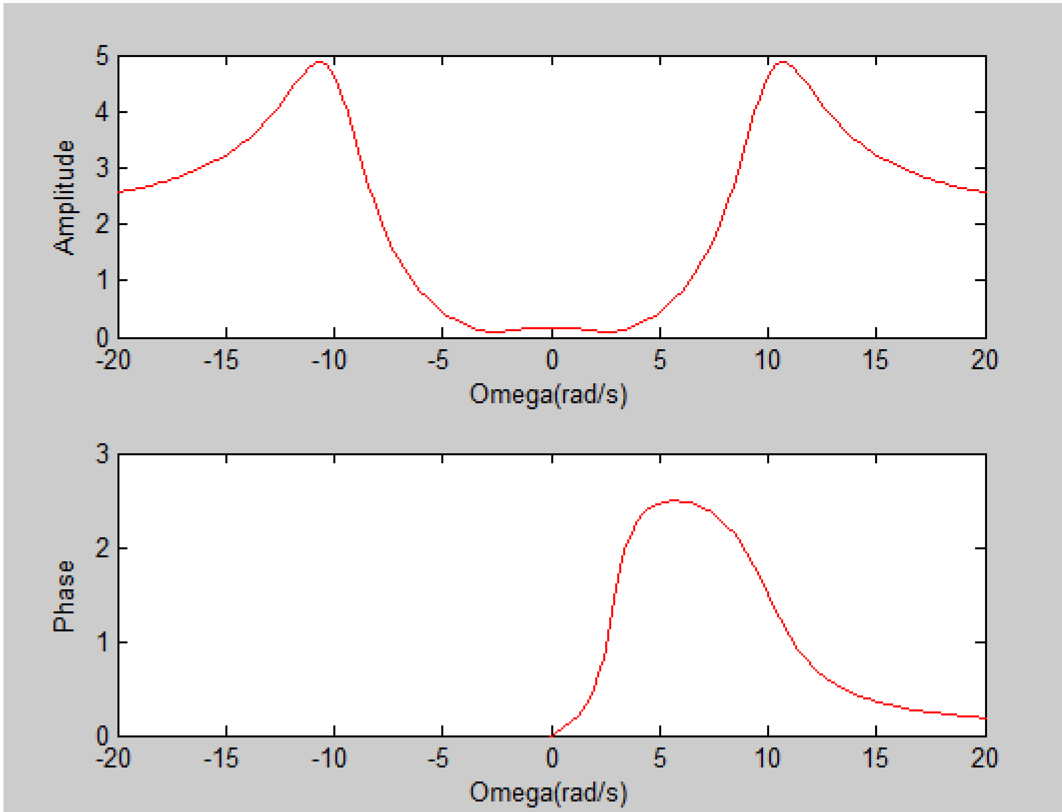

Figure 04

Then, it can be also used the bode plot illustrate the magnitude and the phase for each frequency responses. The bode plot can automatically select the ranges for this task. Following Figure 05 illustrate the result of the bode plot.

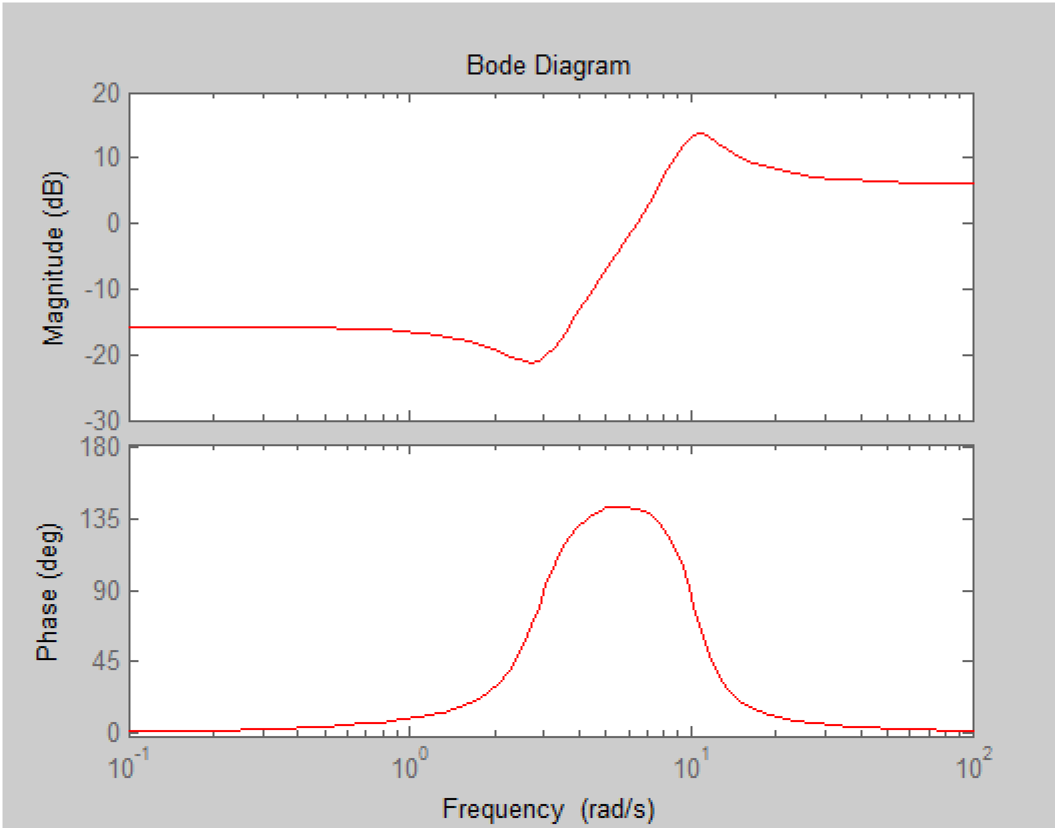

Figure 05

Exercise

1. Bode plots for following four systems have illustrate in the Figure 06
   - $H(s) = (s-1)/(s^2+2s+2)$
   - $H(s) = (s+5)/(s^2+2s+3)$
   - $H(s) = (2s^2+5s+12)/(s^2+2s+10)$
   - $H(s) = (2s^2+5s+12)/(s^2+2s+10)\ (s+2)$

2. For each of these systems, three sinusoidal signals have given as the inputs. Then the Lab03_part2_exercise_2.m MATLAB program will calculate the output in the time domain (y(t)) for given three inputs. (see Figure 7-9)

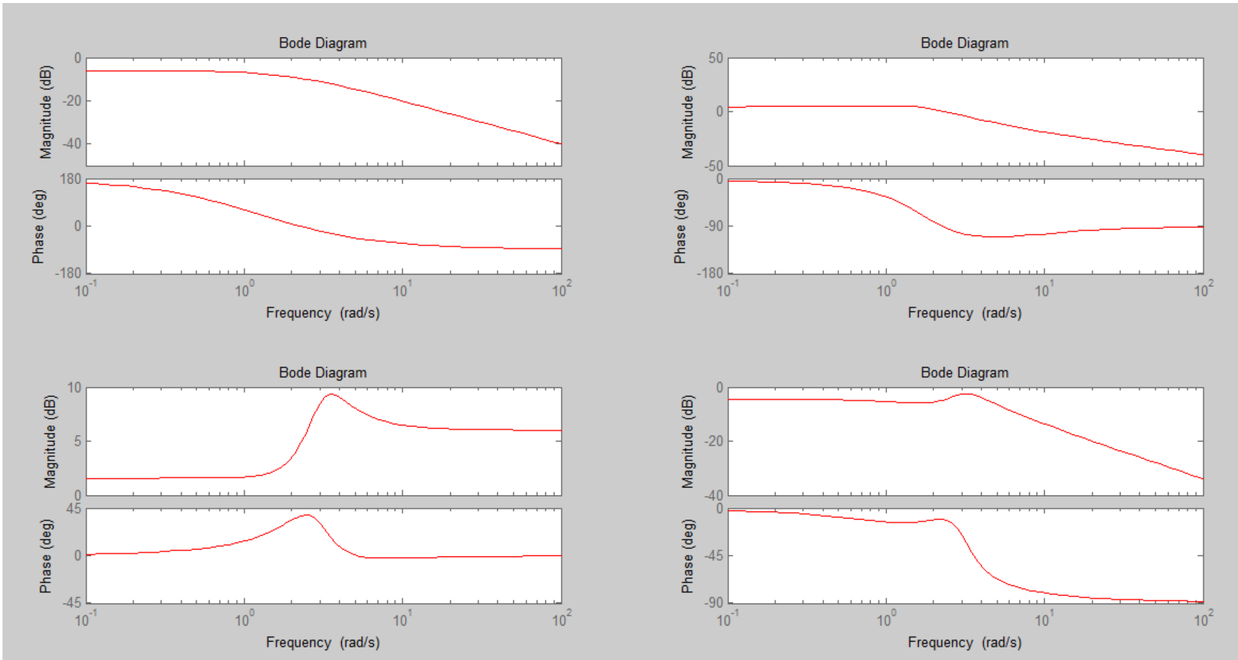

Figure 06

```
Command Window
>> Lab03_part2_exercise_2
************************************************************
Laplace transform of tree signals
L_s1 =
                  s
--------------------------------------
 2   29129930639304447237690902763249
s  + --------------------------------
            18446744073709551616

L_s2 =
                  s
--------------------------------------
 2   29129930639304447237690902763249
s  + --------------------------------
             4611686018427387904

L_s3 =
                  s
--------------------------------------
 2   65542343938435014380627153930521
s  + --------------------------------
             4611686018427387904

************************************************************
```

Figure 07

```
% frequency responces of the systems

h1 = (s-1)/(s^2+2*s+2);
h2 = (s+5)/(s^2+2*s+3);
h3 = (2*s^2+5*s+12)/(s^2+2*s+10);
h4 = (2*s^2+5*s+12)/(s^3+4*s^2+14*s+20);

% multiplication if H(s) and the L(x(t)) give the y(s)
% get the y(s) for all signals
```

Figure 08

```
% multiplication if H(s) and the L(x(t)) give the y(s)
% get the y(s) for all signals

% system 1
y1 = ilaplace(simplify(h1*L_s1));
y2 = ilaplace(simplify(h1*L_s2));
y3 = ilaplace(simplify(h1*L_s3));

% outputs of signals in time domain
display('outputs of signals in time domain for system1 :');
display('y_s1(t)');
pretty(y1);
display('y_s2(t)');
pretty(y2);
display('y_s3(t)');
pretty(y3);
```

Figure 09

PART 3: Surface Plots of a System Function in MATLAB

The complex number s in the Laplace transform is represented as

S = sigma+j*omega

Then it can be use the 3D plot for demonstrate the frequency response H(s) in dB. The Figure 10 illustrate this 3D plot and it can be observed that the zeros in the green region and the plots are in dark red region. If we view this 3D plot in top side we can see that the s domain 2D plot.

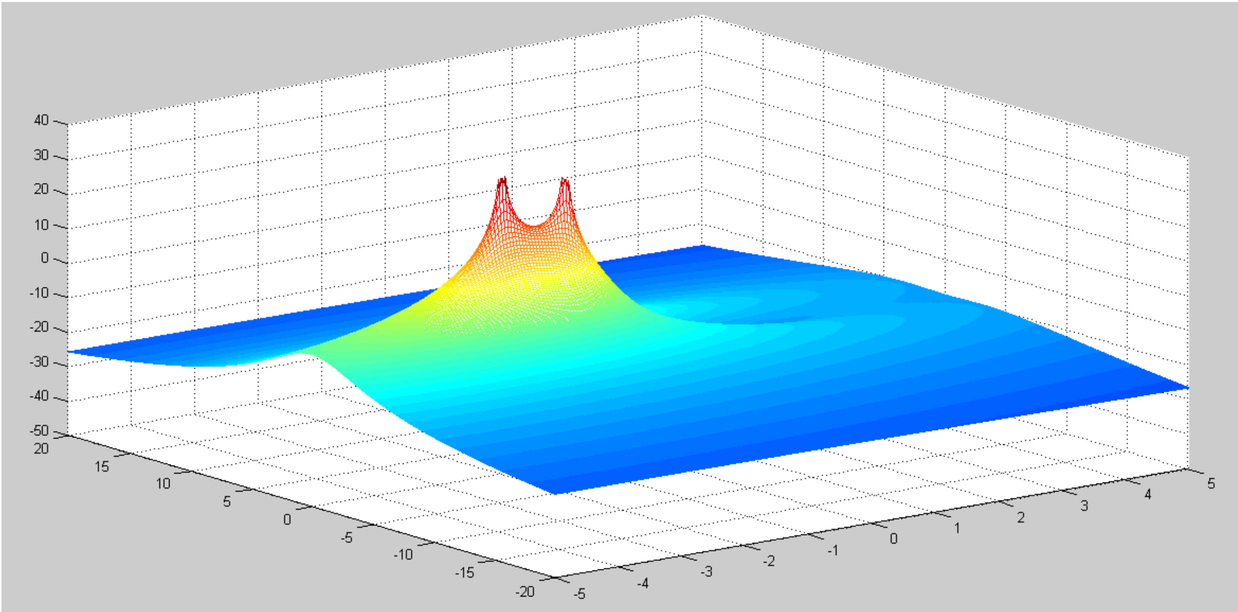

Figure 10

```
clear all;
close all;

% define sigma and omega
sigma = -5:0.05:5;
omega = -20:0.05:20;

%disp(sigma);

[sigmagrid,omegagrid] = meshgrid(sigma,omega); % define the grid
sgrid = sigmagrid+1i*omegagrid;     % define the plain
% disp(sgrid); % display the grid

% H(s) = s-1/(s^2+2*s+2)
b = [1 -1]; % Numerator coefficients
a = [1 3 2]; % Demoninator coefficients

% evaluate the numerator and denominator polynomials at the specific ra
H1 = polyval(b,sgrid)./polyval(a,sgrid); % generate the frequency respo
% disp(H1);
mesh(sigma,omega,20*log10(abs(H1)));
```

Figure 11

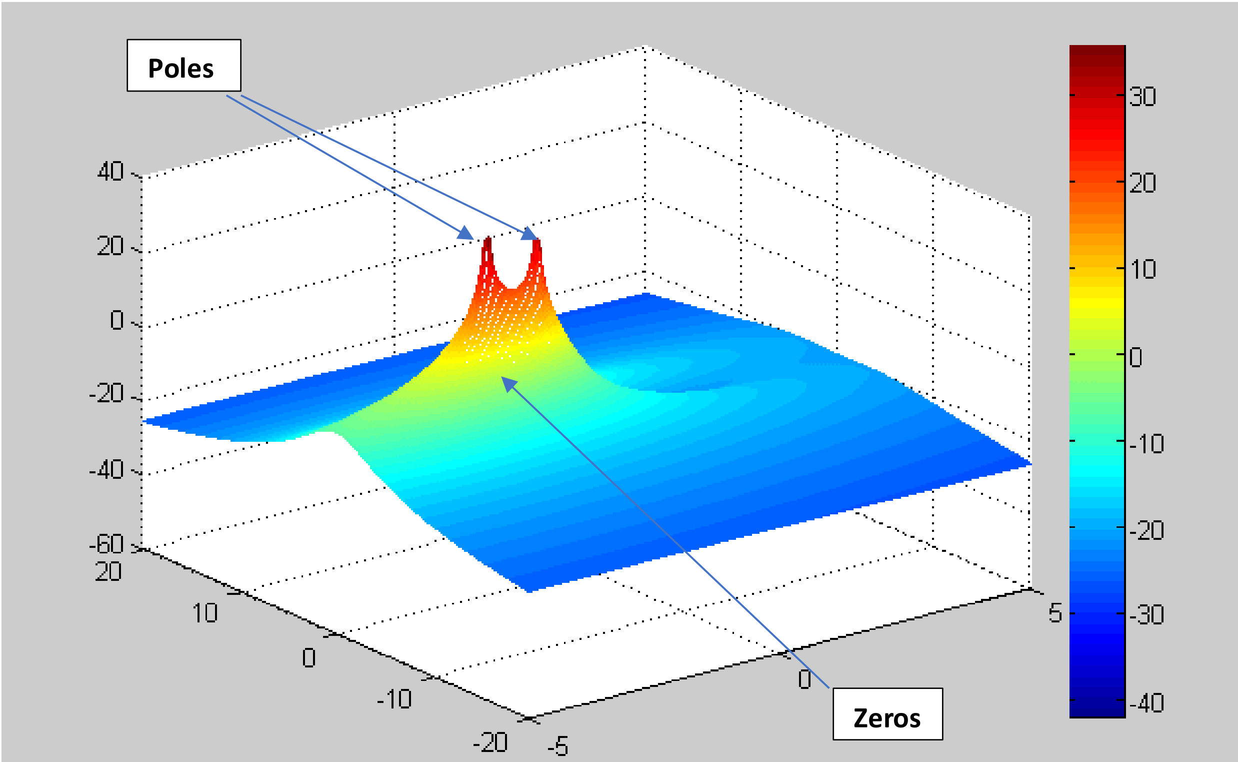

Figure 12