Digital Signal Processing Ⅱ

4^{th} EXPERIMENT

Report

(4th report of DSP2 course)

Subject	Digital Signal Processing Ⅱ
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Exercises

In this part, there are several exercise questions. Each exercise consists of code and its result. All documents including MATLAB code, result, and this report are uploaded in this website :

https://github.com/Gaon-Choi/ELE3077/tree/main/lab_experiment04

Exercise 1

(a) Rearrange $H(z)$ in the form of

$$\frac{b_0 + b_1 z^{-1} + \cdots + b_M z^{-M}}{a_0 + a_1 z^{-1} + \cdots + a_N z^{-N}}$$

by using “residuez” function.

$$H(z) = 2 - \frac{9}{1 - 0.5z^{-1}} + \frac{8}{1 - z^{-1}}$$

$$H(z) = \frac{2(1 - 1.5z^{-1} + 0.5z^{-2}) - 9(1 - z^{-1}) + 8(1 - 0.5z^{-1})}{(1 - 0.5z^{-1})(1 - z^{-1})} = \frac{1 + 2z^{-1} + z^{-2}}{1 - 1.5z^{-1} + 0.5z^{-2}}$$

(MATLAB Code) lab4_exercise1_a.m

```
R = [ -9.0000; 8.0000 ];
p = [ 0.5000; 1.0000 ];
C = 2;

[num, den] = residuez(R, p, C)
```

(Result)

(b) Calculate zeros and poles by using “roots” function.

(MATLAB Code) lab4_exercise1_b.m

```
R = [ -9.0000; 8.0000 ];
p = [ 0.5000; 1.0000 ];
C = 2;

% num: numerator
% den: denominator
[num, den] = residuez(R, p, C);

zeros = roots(num)
poles = roots(den)
```

(Result)

```
명령 창
>> lab4_exercise1_b

zeros =

   -1
   -1


poles =

    1.0000
    0.5000

fx >>
```

(c) Plot the pole-zero plot of $H(z)$ by using “zplane” function and results of Q1-b.

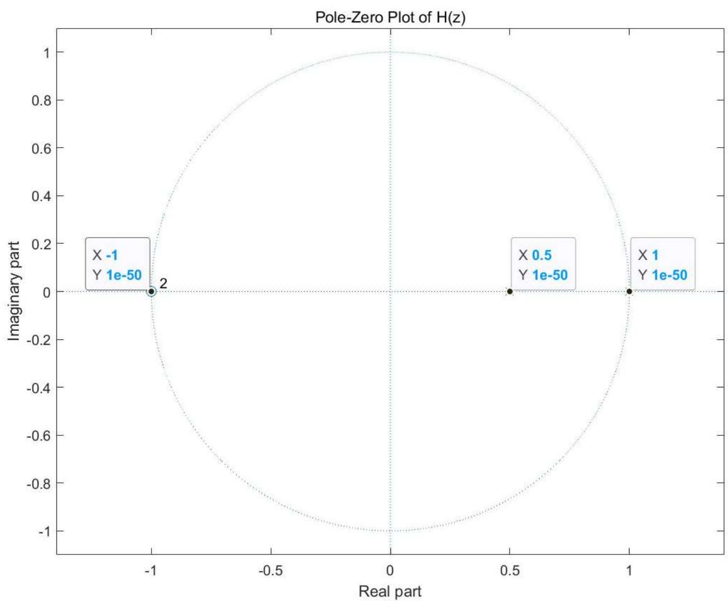
Hint: xlabel(“Real part”), ylabel(“Imaginary part”)

(MATLAB Code) lab4_exercise1_c.m

```
R = [ -9.0000; 8.0000 ];
p = [ 0.5000; 1.0000 ];
C = 2;

% num: numerator
% den: denominator
[num, den] = residuez(R, p, C);

zeros = roots(num);
poles = roots(den);

zplane(zeros, poles)
zplane(num, den)
```

```
xlabel("Real part");
ylabel("Imaginary part");
title("Pole-Zero Plot of H(z)");
```

(Result)

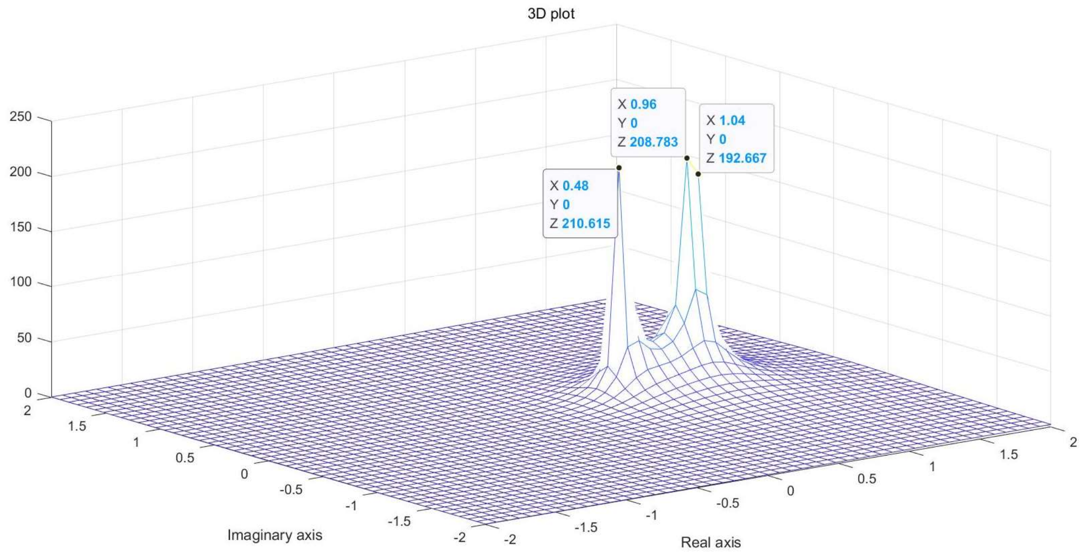


(d) Plot the 3D graphs of $H(z)$.

(MATLAB Code) lab4_exercise1_d.m

```
x = linspace(-2, 2, 51);
y = linspace(-2, 2, 51);
[X, Y] = meshgrid(x, y);

z = X + 1j * Y;
Z = abs(2 - (9 ./ (1 - 0.5*(s.^-1))) + (8 ./ (1-(s.^-1))));
mesh(X, Y, abs(Z));
title("3D plot");

xlabel("Real axis");
ylabel("Imaginary axis");
```

(Result)



3D plot
X 0.96
Y 0
Z 208.783
X 1.04
Y 0
Z 192.667
X 0.48
Y 0
Z 210.615
250
200
150
100
50
0
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
Imaginary axis
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
Real axis

Exercise 2

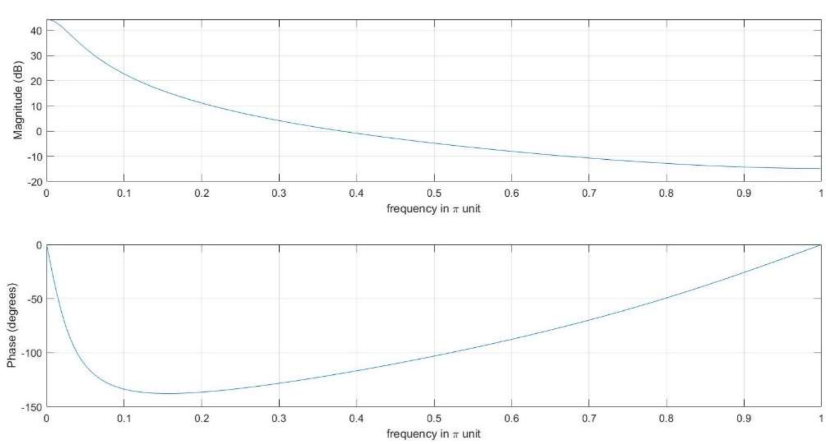
(a) Using freqz with $N = 512$, make the plots of the magnitude and phase responses $|H(\Omega)|$ and $\angle H(\Omega)$ for $0 \leq \Omega \leq \pi$.

$$H(z) = \frac{1 + \frac{1}{3}z^{-1}}{1 - 1.85\cos\left(\frac{\pi}{18}\right)z^{-1} + 0.83z^{-2}}$$

(MATLAB Code) lab4_exercise2_a.m

```
num = [ 1, 1/3 ];  % numerator
den = [ 1, -1.85 * cos(pi / 18), 0.83 ];  % denominator

N = 512;
[h,w] = freqz(num, den, N);

mag_h = abs(h);
mag_h = 20 * log10(mag_h);
ang_h = angle(h);

subplot(2, 1, 1);
plot(w/pi, mag_h);
xlabel("frequency in \pi unit");
ylabel("Magnitude (dB)");
grid on

subplot(2, 1, 2);
plot(w/pi, ang_h * 180/pi);
xlabel("frequency in \pi unit");
ylabel("Phase (degrees)");
grid on
```

(Result)



(b) Explain what type of filter this system represents briefly.

(i.e. lowpass, highpass, bandpass, etc.)

The range of frequency is $\mathbb{R} \in [-\pi, \pi]$. According to the result of (a), the magnitude of $X(w)$ decreases as the frequency increases. It means that lower-frequency information passes, while higher-frequency information is blocked, thus $X(w)$ is a low-pass filter.