Hacettepe University

Department of Electrical and Electronics Engineering

ELE 409 Digital Signal Proccessing Laboratory

EXPERIMENT 2 – ANALYSIS of DISCRETE-TIME SYSTEMS PRELIMINARY WORK

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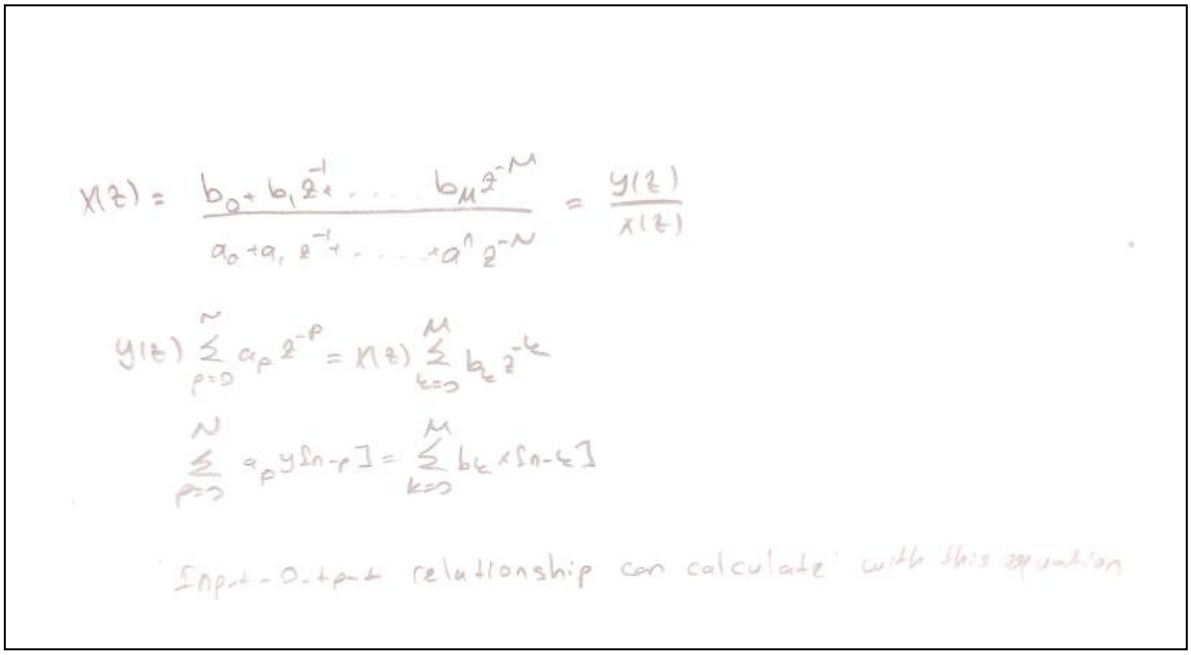
14/11/2022

1)

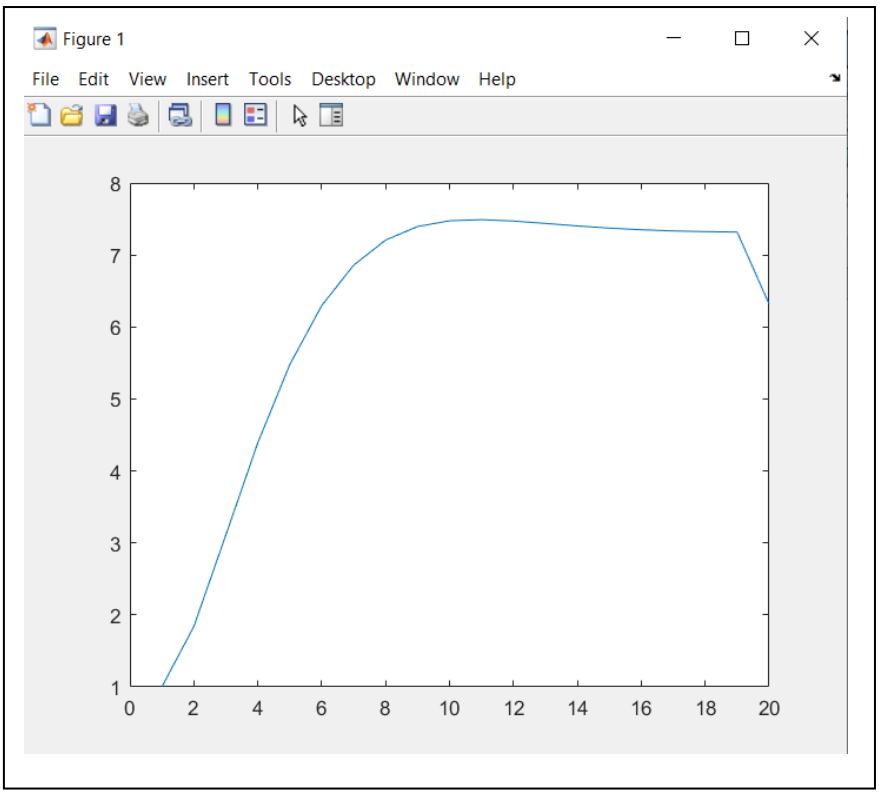


2)

Matlab Code:

```
function y= inout(b,a,x,L)
for n=1:L
    temp_x=0;
    temp_y=0;
    for i=1:length(b)
        if(n-i+1)>0
            if(n-i+1)<length(x)
                temp_x=temp_x+b(i)*x(n-i+1);
            end
        end
    end
    for i=2:length(a)
        if(n-i+1)>0
            temp_y=temp_y+a(i)*y(n-i+1);
        end
        y(n)=(temp_x-temp_y)/a(1);
    end
end
```

```
close all;
clear all;
clc;
a=[1 -1.3335 0.49];
b=[1 -0.4944 0.64];
x=ones(1,20);
L=20;
y=inout(b,a,x,L);
plot(y);
```



Y :

1x20 double

	1	2	3	4	5	6	7	8	9	10
1	1	1.8391	3.1080	4.3890	5.4754	6.2964	6.8590	7.2068	7.3949	7.4754

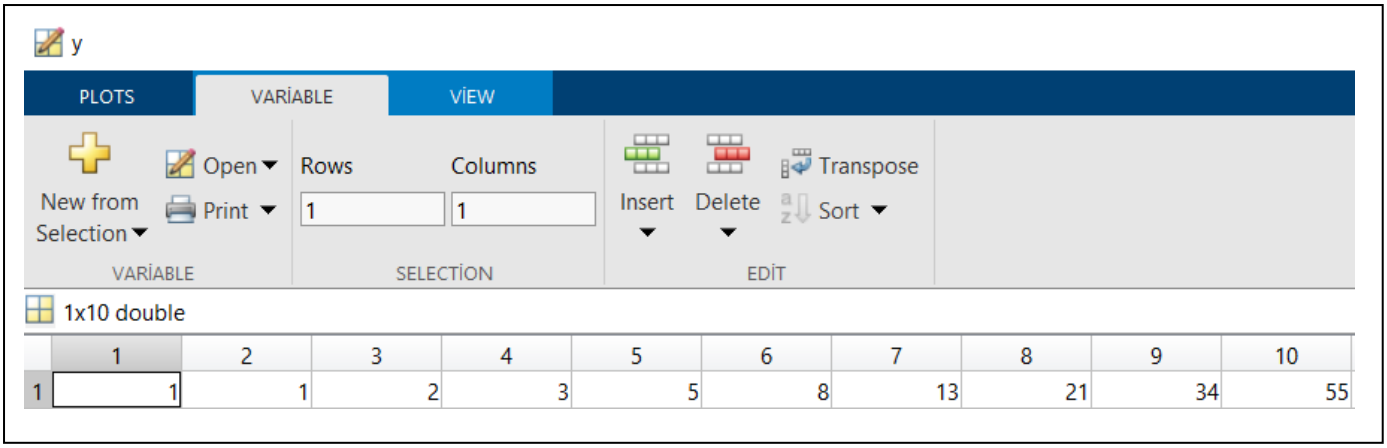
11	12	13	14	15	16	17	18	19	20
7.4906	7.4713	7.4382	7.4035	7.3735	7.3504	7.3344	7.3243	7.3187	6.3162

3)

Matlab Code :

```
function  y  = myAR( x,a )
    length_x = length(x);
    if length_x == 1
       y(1) = x(1);
    else
       y = myAR(x(1:length_x-1),a);
       y(length_x) = x(length_x)-sum(a(1:length_x-1).*y(length_x-1:-1:1));
    end
end
```

```
clear all;
clc;
close all;
K=10;
x=zeros(1,K);
x(1)=1;
a=zeros(1,K);
a(1)=-1;
a(2)=-1;
y = myAR(x,a)
```



	1	2	3	4	5	6	7	8	9	10
1	1	1	2	3	5	8	13	21	34	55

4)

Matlab Code :

```
function [y]=myMA(x,b)
    zerosmatris1=zeros(1,length(x)-1);
    zerosmatris2=zeros(1,length(x)-length(b))
    x_axis=[b(1) zerosmatris1];
    y_axis=[b zerosmatris2];
    toeplitz_xy=toeplitz(y_axis,x_axis);
    y=toeplitz_xy*x';
end
```

```
clc;
clear all;
close all;
x=[1:1:10];
b1=[1 -1];
b2=[1 -2 1];
y1=myMA(x,b1);
y2=myMA(x,b2);
y1=y1'
y2=y2'
```

y1:

1x10 double

	1	2	3	4	5	6	7	8	9	10
1	1	1	1	1	1	1	1	1	1	1

y2:

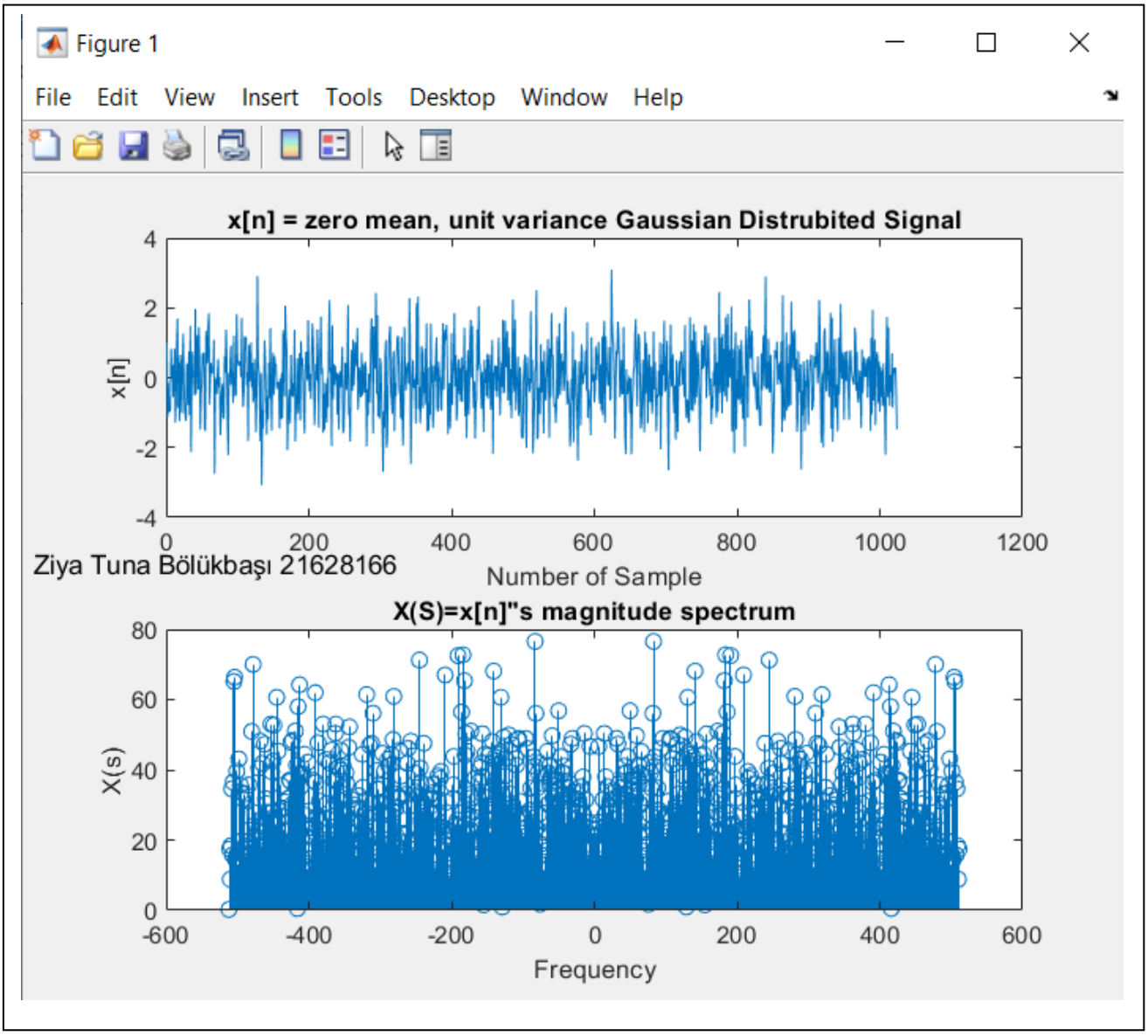
1x10 double

	1	2	3	4	5	6	7	8	9	10
1	1	0	0	0	0	0	0	0	0	0

5)

Matlab Code

```
clc;
clear all;
close all;
x=randn(1,1024);
fft_x=fft(x);
fft_shift_x=fftshift(abs(fft_x));
fs=1024;
range_of_frequency=-fs/2:fs/1024:fs/2-fs/1024;
subplot(2,1,1);
plot(x);
title('x[n] = zero mean, unit variance Gaussian Distrubited Signal');
xlabel('Number of Sample');
ylabel('x[n]');
subplot(2,1,2);
stem(range_of_frequency,abs(fft_shift_x));
title('X(S)=x[n]"s magnitude spectrum'),xlabel('Frequency'),ylabel('X(s)');
```



6)

Matlab Code:

```
clc;
clear all;
close all;
x = randn(1,1024);
fft_x=fft(x);
fft_shift_x=fftshift(abs(fft_x));
fs=1024;
range_of_frequency=-fs/2:fs/1024:fs/2-fs/1024;
L=1024;
b1 = [1 -0.4944 0.64];
b2 = [1 0.4944 0.64];
a1 = [1 -1.3335 0.49];
a2 = [1 1.3335 0.49];
y1=inout(b1,a1,x,L);
y2=inout(b2,a2,x,L);
y3= y1 + y2;
fft_y1=fft(y1);
fft_y2=fft(y2);
fft_y3=fft(y3);
fft_shift_y1 = fftshift(abs(fft_y1));
fft_shift_y2 = fftshift(abs(fft_y2));
fft_shift_y3 = fftshift(abs(fft_y3));
y4=fft_shift_y1.*fft_shift_y2;
figure;
subplot(2,1,1);
stem(range_of_frequency,fft_shift_y1);
title('Y1(S)=y1[n]s magnitude spectrum');
xlabel('Number of Sample');
ylabel('|Y1(s)|');
subplot(2,1,2);
stem(range_of_frequency,fft_shift_y2);
title('Y2(S)=y2[n]s magnitude spectrum');
xlabel('Frequency');
ylabel('|Y2(s)|');
gtext('Ziya Tuna Bölükbaşı 21628166');
figure;
subplot(2,1,1);
stem(range_of_frequency,fft_shift_y3);
title('Combine the two systems in parallel');
xlabel('Frequency');
ylabel('|Y3(s)|');
subplot(2,1,2);
stem(range_of_frequency,y4);
title('Combine the two systems in a cascade manner');
xlabel('Frequency');
ylabel('|Y4(s)|');
gtext('Ziya Tuna Bölükbaşı 21628166');
```

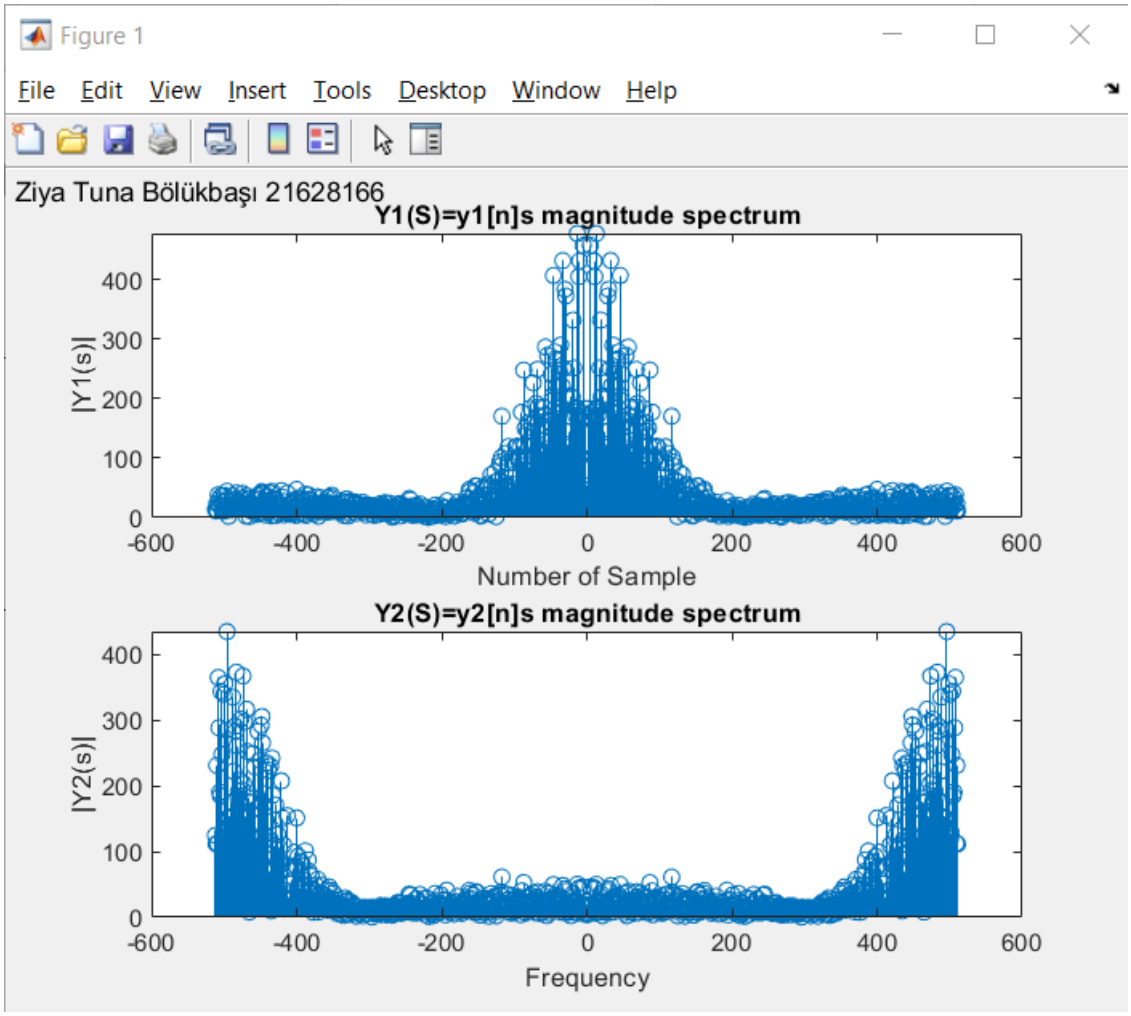


Figure 1
File Edit View Insert Tools Desktop Window Help
Ziya Tuna Bölükbaşı 21628166
Y1(S)=y1[n]s magnitude spectrum
|Y1(s)|
Number of Sample
Y2(S)=y2[n]s magnitude spectrum
|Y2(s)|
Frequency

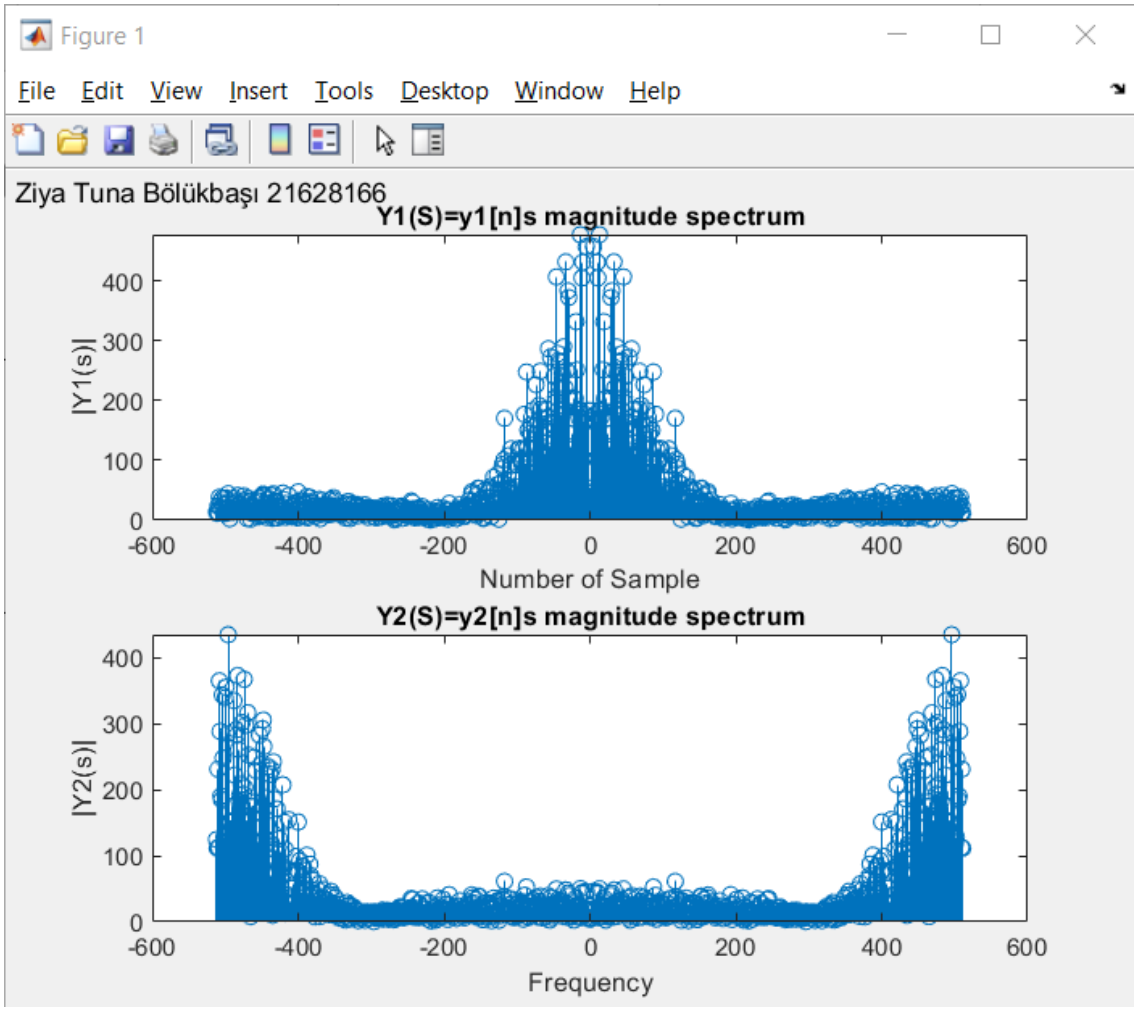


Figure 1
File Edit View Insert Tools Desktop Window Help
Ziya Tuna Bölükbaşı 21628166
Y1(S)=y1[n]s magnitude spectrum
|Y1(s)|
Number of Sample
Y2(S)=y2[n]s magnitude spectrum
|Y2(s)|
Frequency

First filter is a low-pass filter.Second filter is a high-pass filter.Output is equal to total of filters' output if connect them in paralel.Output of connecting them in series is a attenuated version of original signal because signal first goes through low-pass filter and then high-pass filter.

7)

Matlab Code:

```
clc;
clear all;
close all;
a=0.8*[exp(0.1*pi*i) exp(-0.1*pi*i)];
b=0.8*[exp(0.5*pi*i) exp(-0.5*pi*i)];
c=0.8*[exp(0.9*pi*i) exp(-0.9*pi*i)];
d=0.1*[exp(0.5*pi*i) exp(-0.5*pi*i)];
e=0.9*[exp(0.5*pi*i) exp(-0.5*pi*i)];
p_a=poly(abs(a));
p_b=poly(abs(b));
p_c=poly(abs(c));
p_d=poly(abs(d));
p_e=poly(abs(e));
figure;subplot(1,1,1),freqz(1,p_a,100);
title('Frequency response of A');
gtext('Ziya Tuna Bölükbaşı 21628166');
figure;subplot(1,1,1),freqz([1,p_b,100]);
title('Frequency response of B');
gtext('Ziya Tuna Bölükbaşı 21628166');
figure;subplot(1,1,1),freqz([1 p_c,100]);
title('Frequency response of C');
gtext('Ziya Tuna Bölükbaşı 21628166');
figure;subplot(1,1,1),freqz(1,p_d,100);
title('Frequency response of D');
gtext('Ziya Tuna Bölükbaşı 21628166');
figure;subplot(1,1,1),freqz(1,p_e,100);
title('Frequency response of E');
gtext('Ziya Tuna Bölükbaşı 21628166');
```

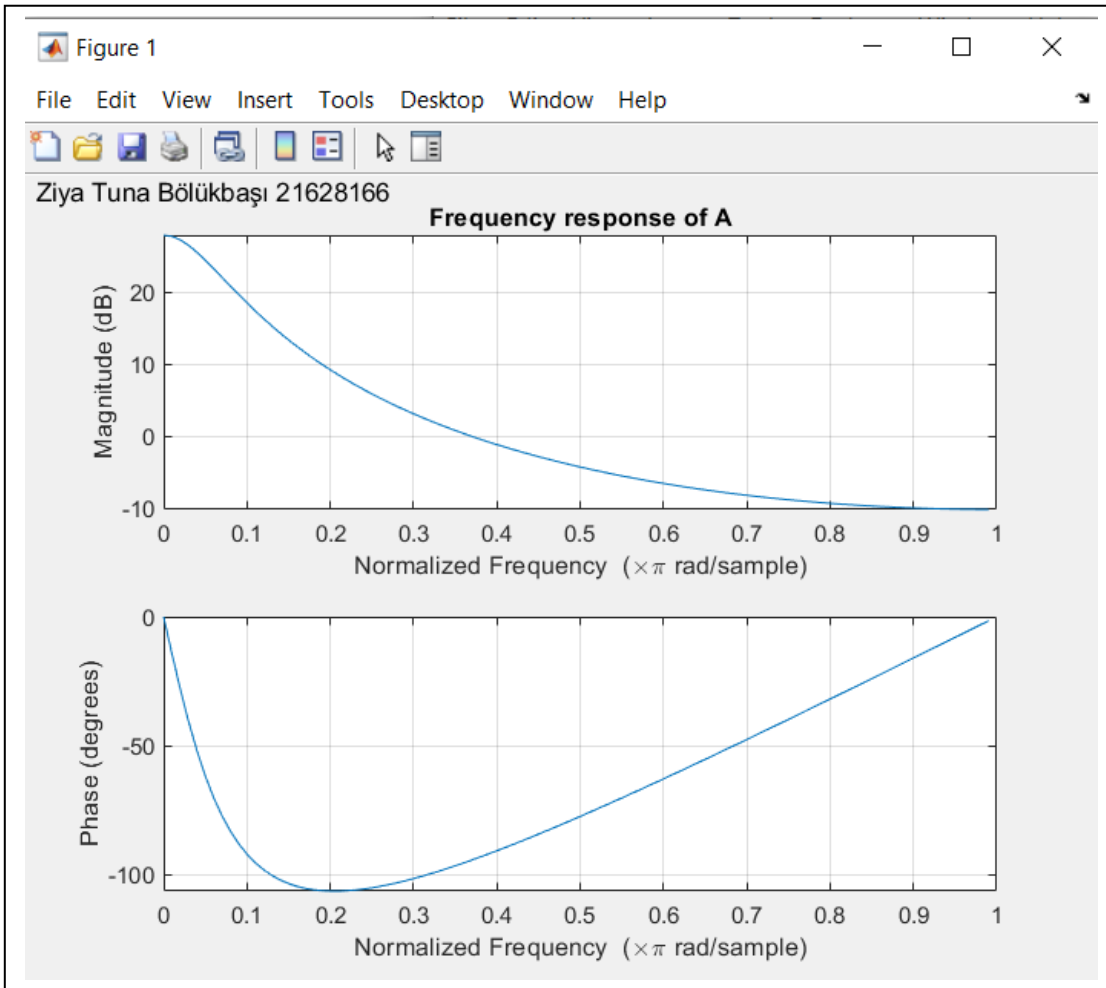


Figure 1
File Edit View Insert Tools Desktop Window Help
Ziya Tuna Bölükbaşı 21628166
Frequency response of A
Magnitude (dB)
20
10
0
-10
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)
Phase (degrees)
0
-50
-100
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)

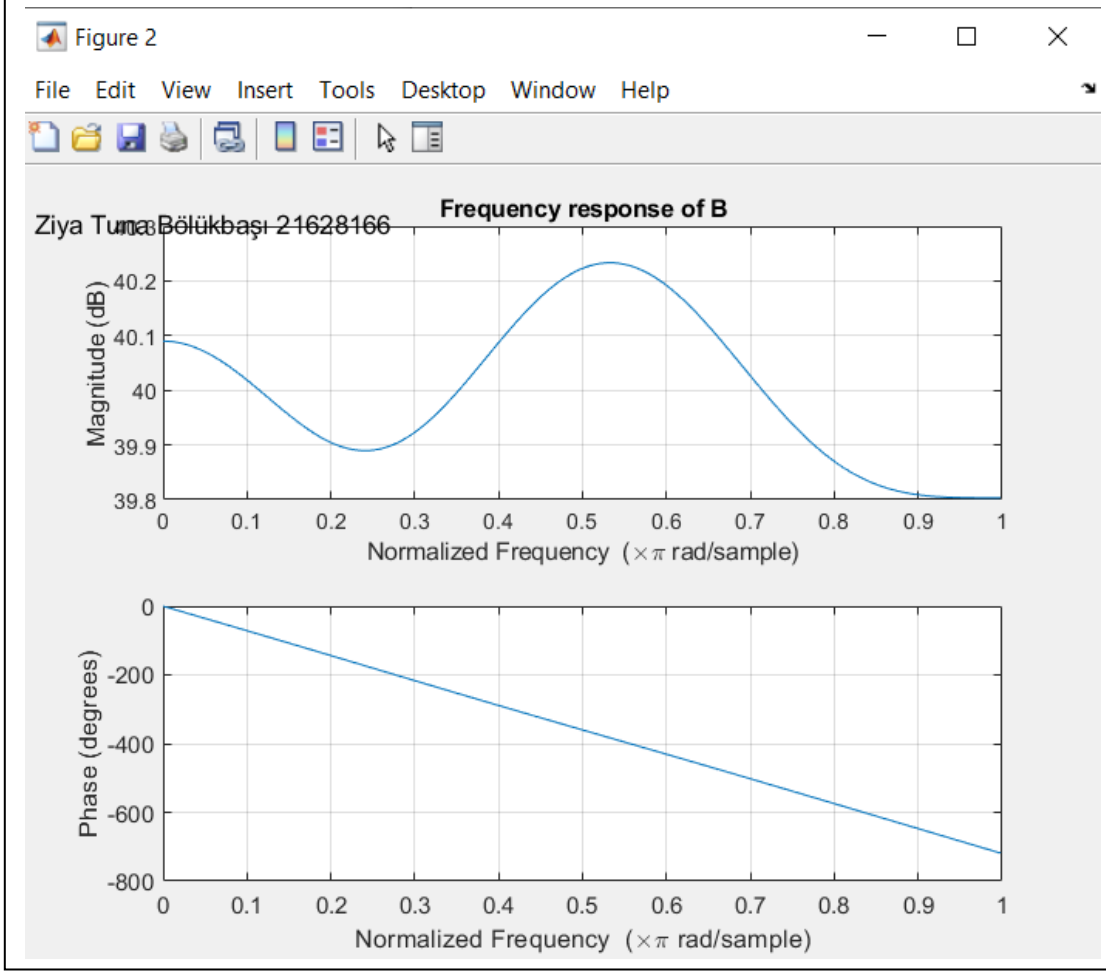


Figure 2
File Edit View Insert Tools Desktop Window Help
Ziya Tuna Bölükbaşı 21628166
Frequency response of B
Magnitude (dB)
40.2
40.1
40
39.9
39.8
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)
Phase (degrees)
0
-200
-400
-600
-800
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)

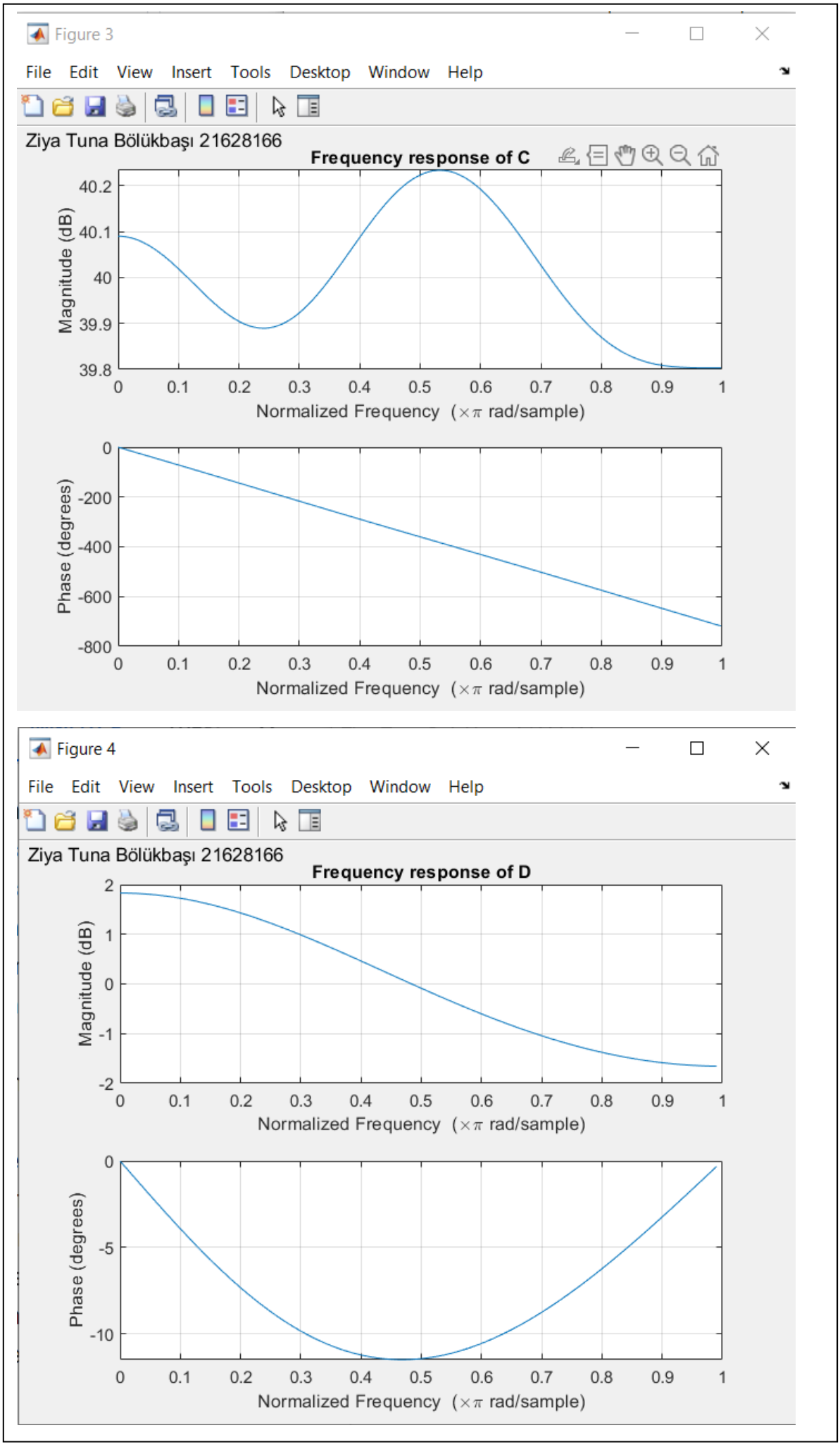
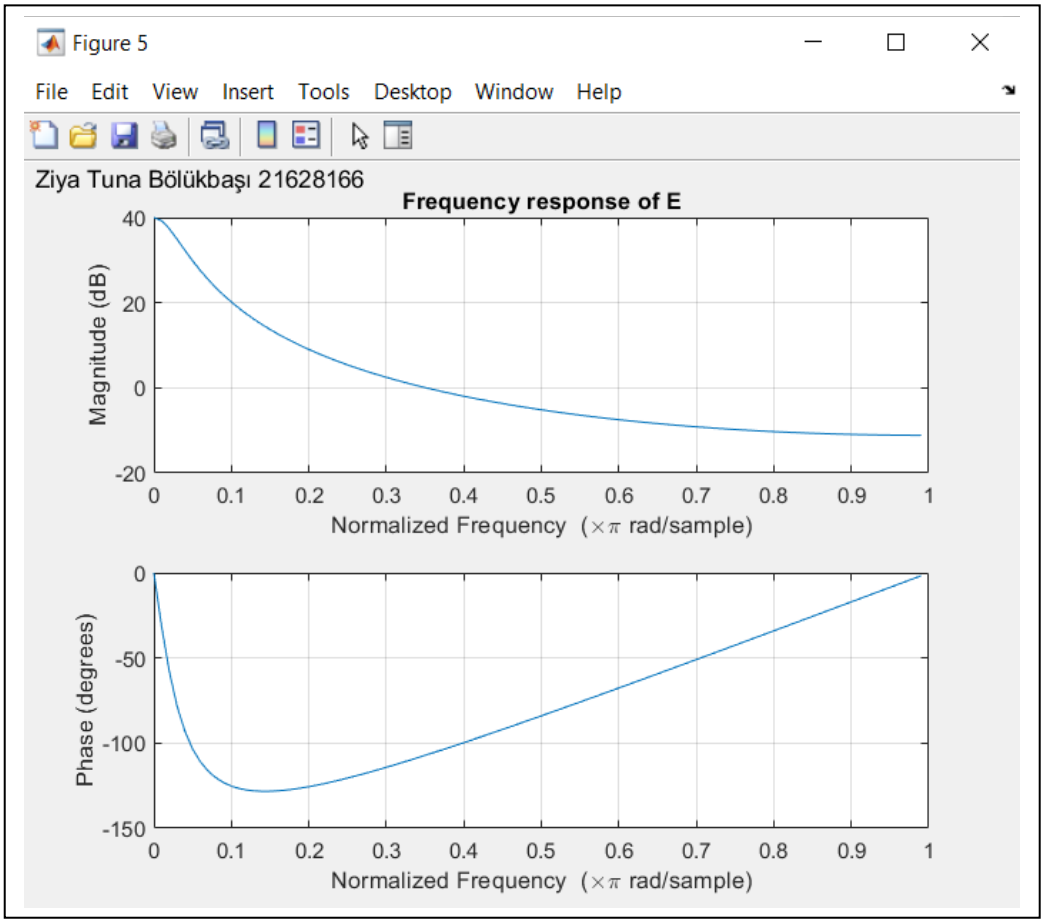


Figure 3
File Edit View Insert Tools Desktop Window Help
Ziya Tuna Bölükbaşı 21628166
Frequency response of C
Magnitude (dB)
40.2
40.1
40
39.9
39.8
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)
Phase (degrees)
0
-200
-400
-600
-800
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)
Figure 4
File Edit View Insert Tools Desktop Window Help
Ziya Tuna Bölükbaşı 21628166
Frequency response of D
Magnitude (dB)
2
1
0
-1
-2
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)
Phase (degrees)
0
-5
-10
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)



Magnitude spectrum increases as poles approach unit circle.

8)

Matlab Code

```
clc;
clear all;
close all;

num_a = [1 0.7264 0.64];
den_a = [1 -0.6356 0.49];

figure; zplane(num_a,den_a);
title('Z-plane of First System Response');
gtext('Ziya Tuna Bölükbaşı 21628166');

figure; impz(num_a,den_a,30);
title('First Impulse Response');
gtext('Ziya Tuna Bölükbaşı 21628166');

figure; stepz(num_a,den_a,30);
title('First Step Response');
gtext('Ziya Tuna Bölükbaşı 21628166');

num_b =[1 1.135 1.5625];
den_b = [1 -0.6356 0.49];

figure; zplane(num_b,den_b);
title('Z-plane of First Second Response');
gtext('Ziya Tuna Bölükbaşı 21628166');

figure; impz(num_b,den_b,30);
title('Second Impulse Response');
gtext('Ziya Tuna Bölükbaşı 21628166');

figure; stepz(num_b,den_b,30);
title('Second Step Response');
gtext('Ziya Tuna Bölükbaşı 21628166');

num_c =[1 0.7264 0.64];
den_c = [1 -1.362 2.25];

figure; zplane(num_c,den_c);,
title('Z-plane of Third System Response');
gtext('Ziya Tuna Bölükbaşı 21628166');

figure; impz(num_c,den_c,30);
title('Third Impulse Response');
gtext('Ziya Tuna Bölükbaşı 21628166');

figure; stepz(num_c,den_c,30);
title('Third Step Response');
gtext('Ziya Tuna Bölükbaşı 21628166');
```

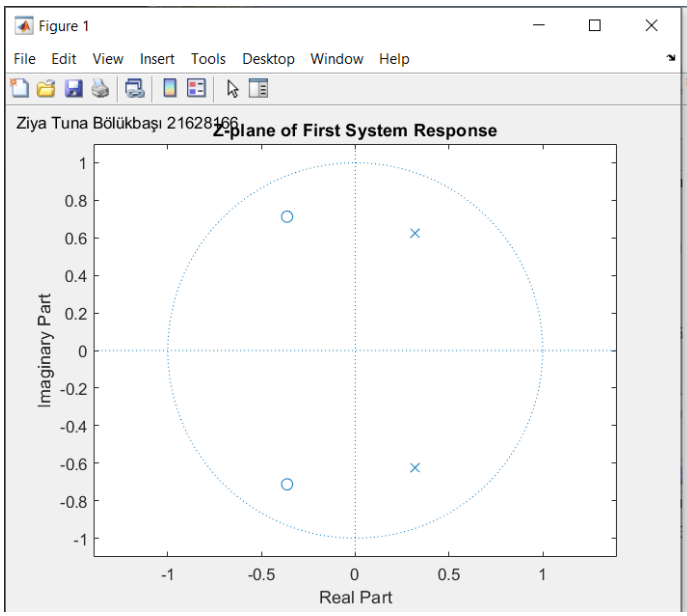


Figure 1
File Edit View Insert Tools Desktop Window Help
Ziya Tuna Bölükbaşı 21628166
Z-plane of First System Response
Imaginary Part
Real Part

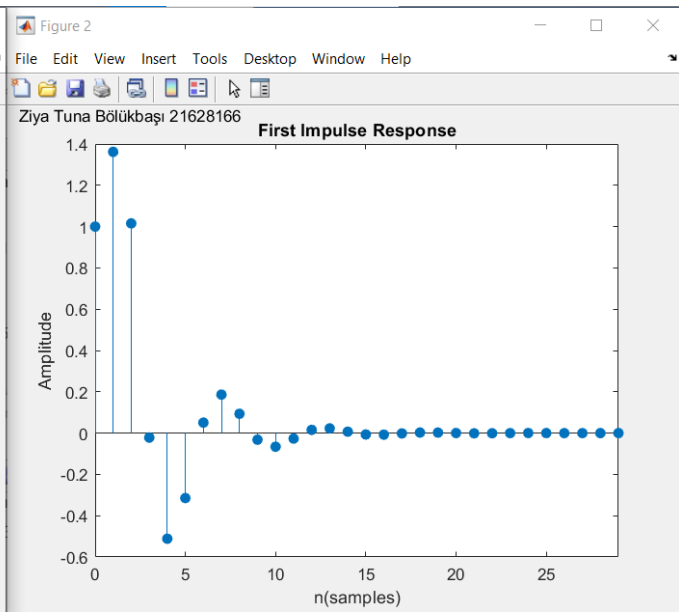


Figure 2
File Edit View Insert Tools Desktop Window Help
Ziya Tuna Bölükbaşı 21628166
First Impulse Response
Amplitude
n(samples)

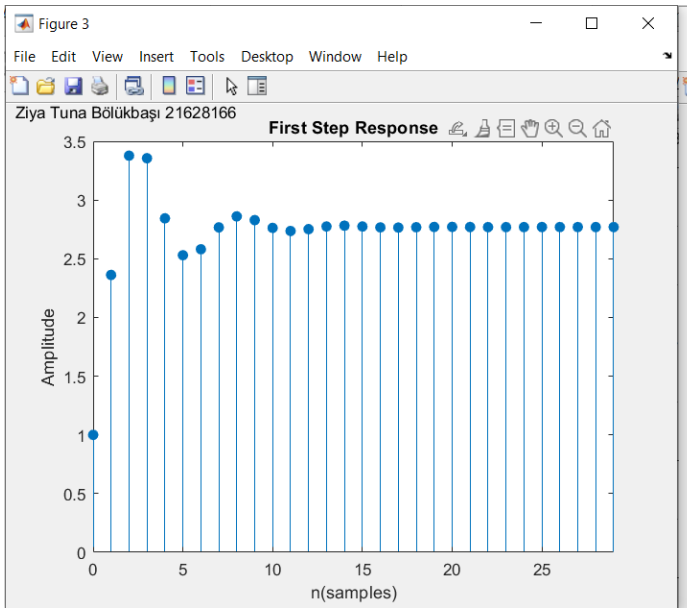


Figure 3
File Edit View Insert Tools Desktop Window Help
Ziya Tuna Bölükbaşı 21628166
First Step Response
Amplitude
n(samples)

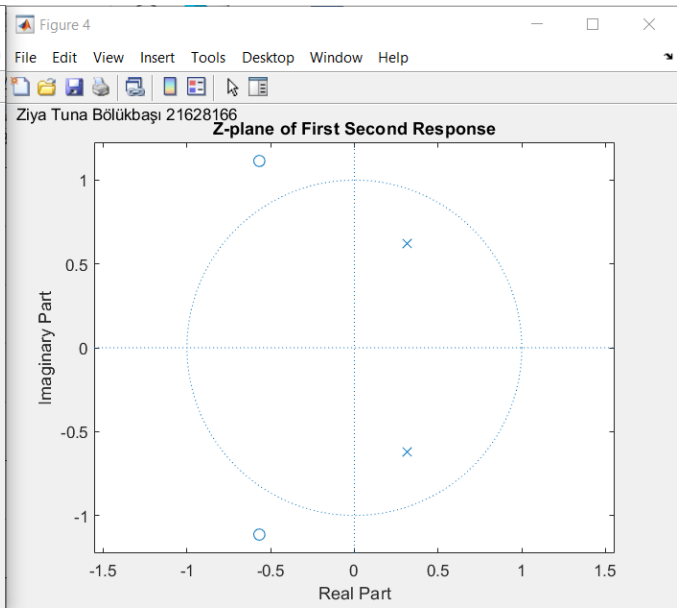


Figure 4
File Edit View Insert Tools Desktop Window Help
Ziya Tuna Bölükbaşı 21628166
Z-plane of First Second Response
Imaginary Part
Real Part

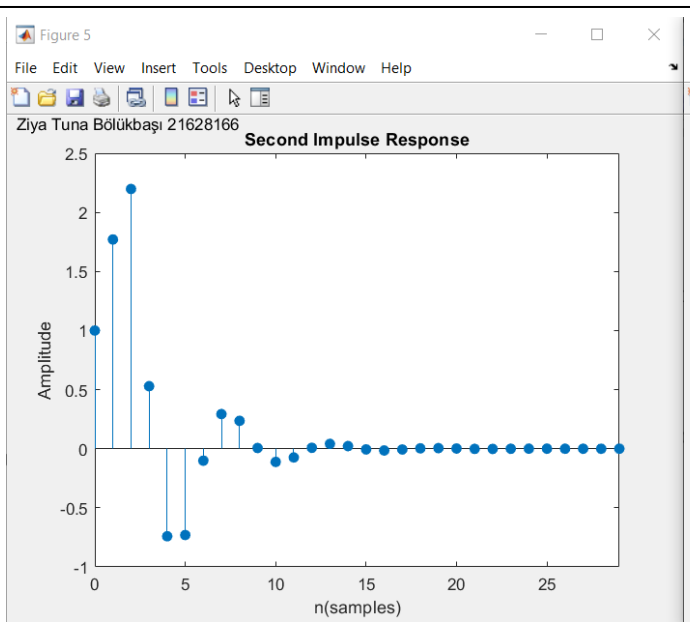


Figure 5
File Edit View Insert Tools Desktop Window Help
Ziya Tuna Bölükbaşı 21628166
Second Impulse Response
Amplitude
n(samples)

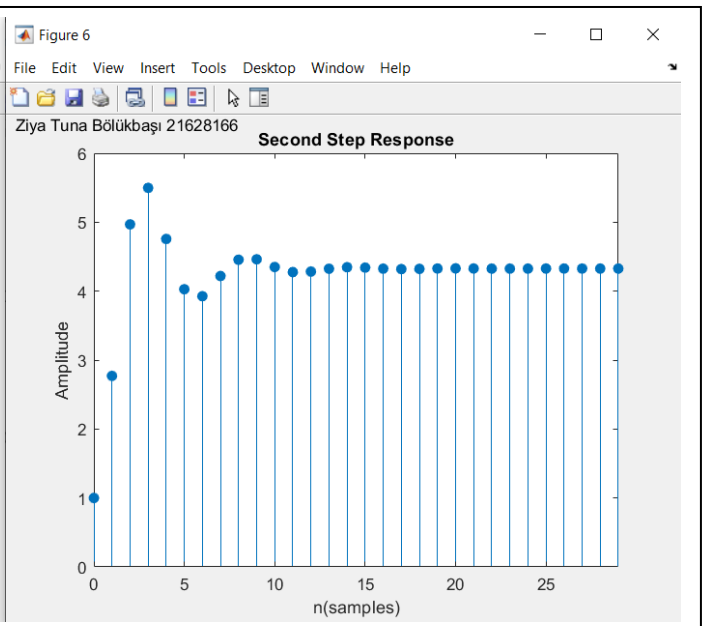
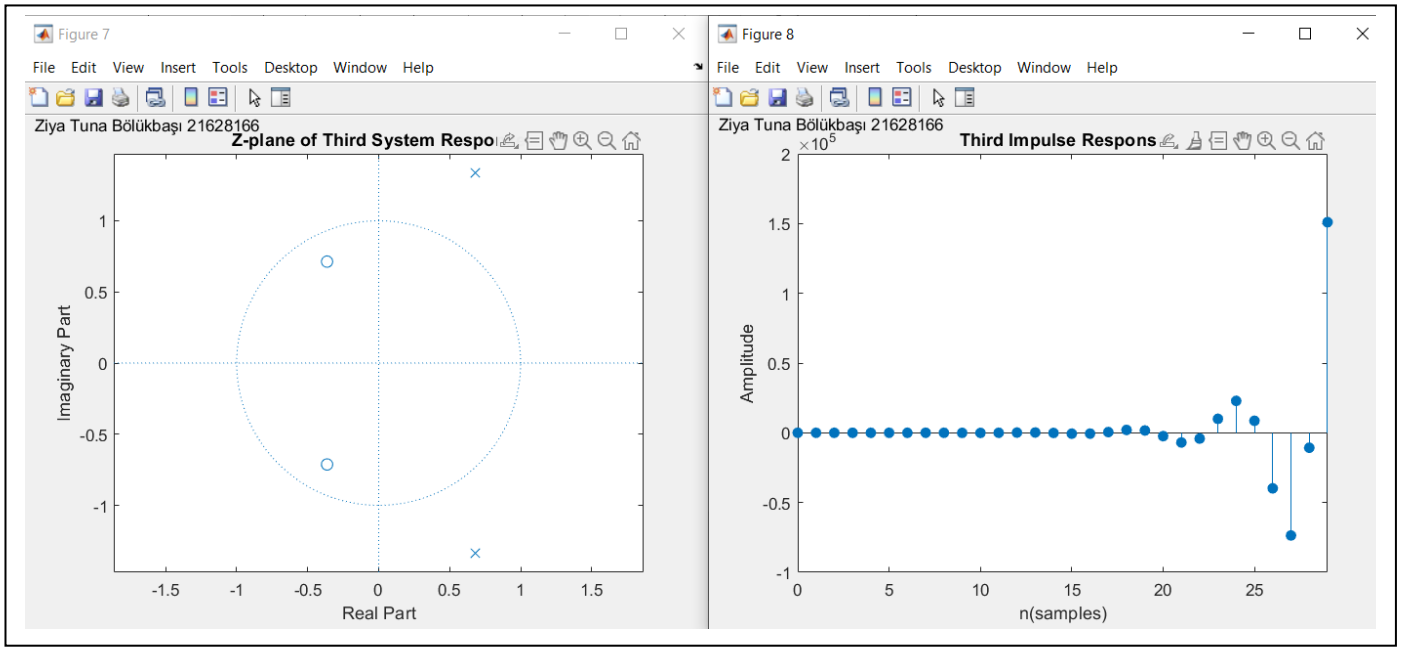
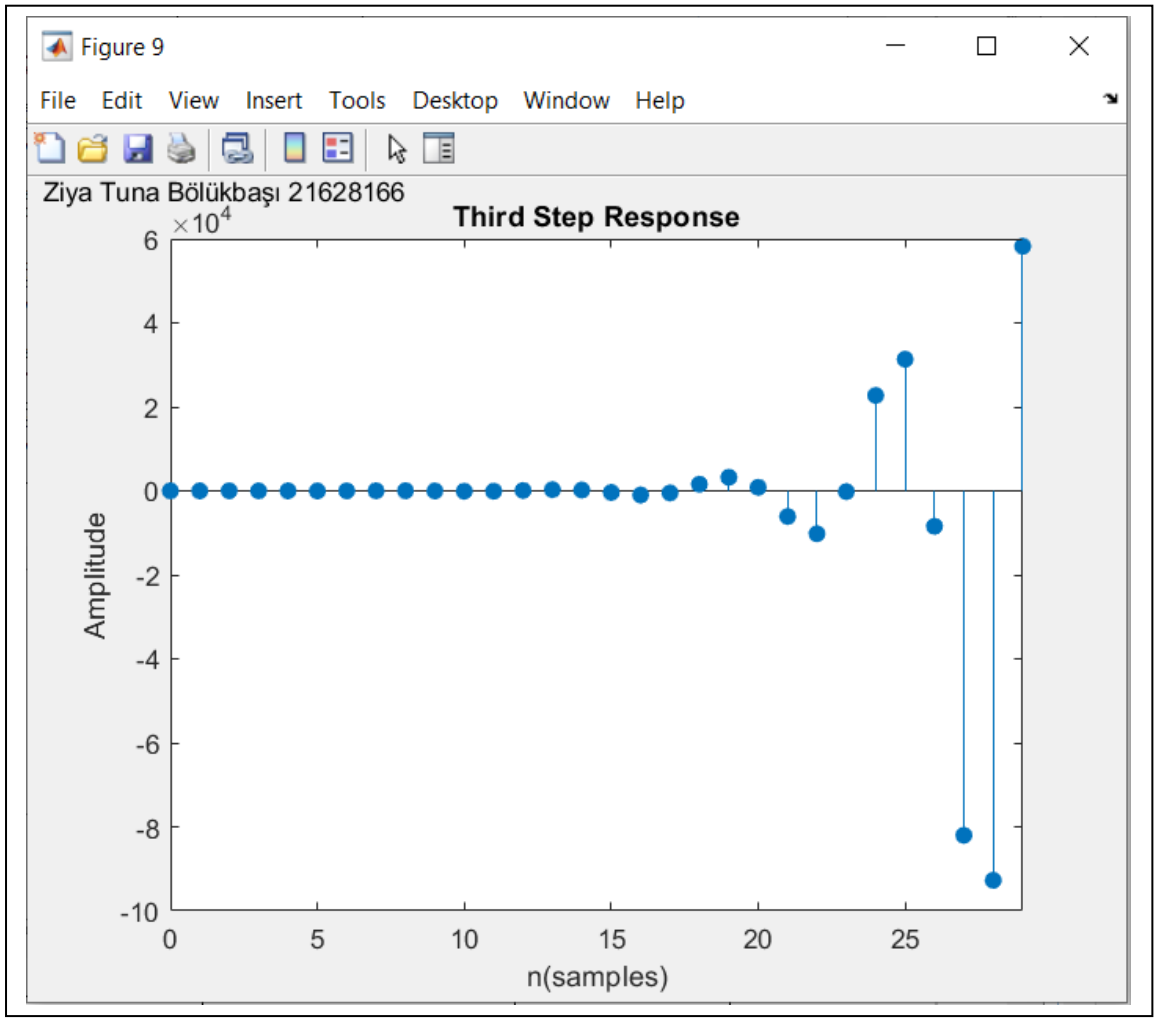


Figure 6
File Edit View Insert Tools Desktop Window Help
Ziya Tuna Bölükbaşı 21628166
Second Step Response
Amplitude
n(samples)





First system is stable because unit circle and all poles in ROC contain unit circle. So system is Minimum Phase Systems.

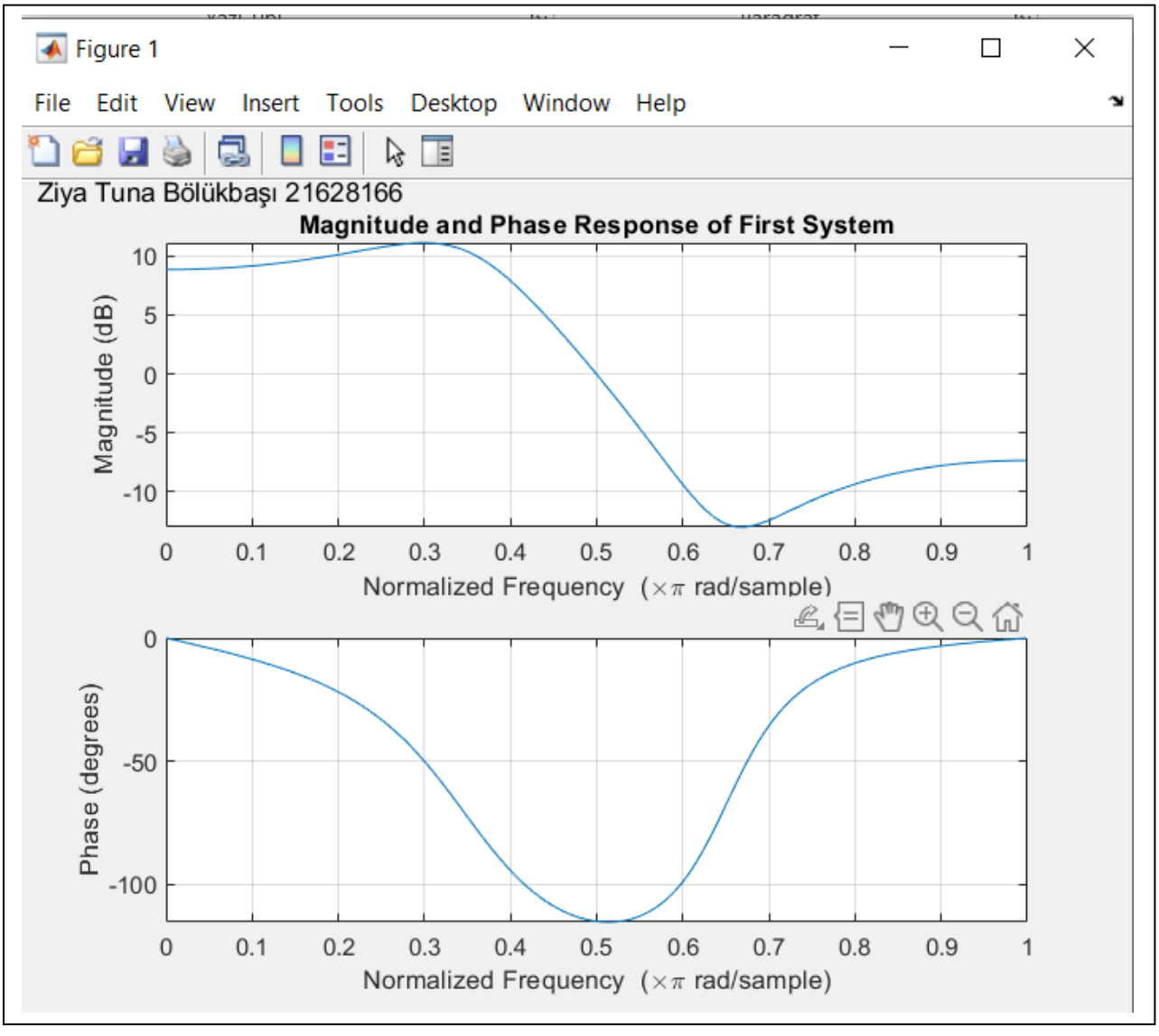
Since poles are inside unit circle, second system is stable but Zeros are outside unit circle. So system is not Minimum Phase Systems.

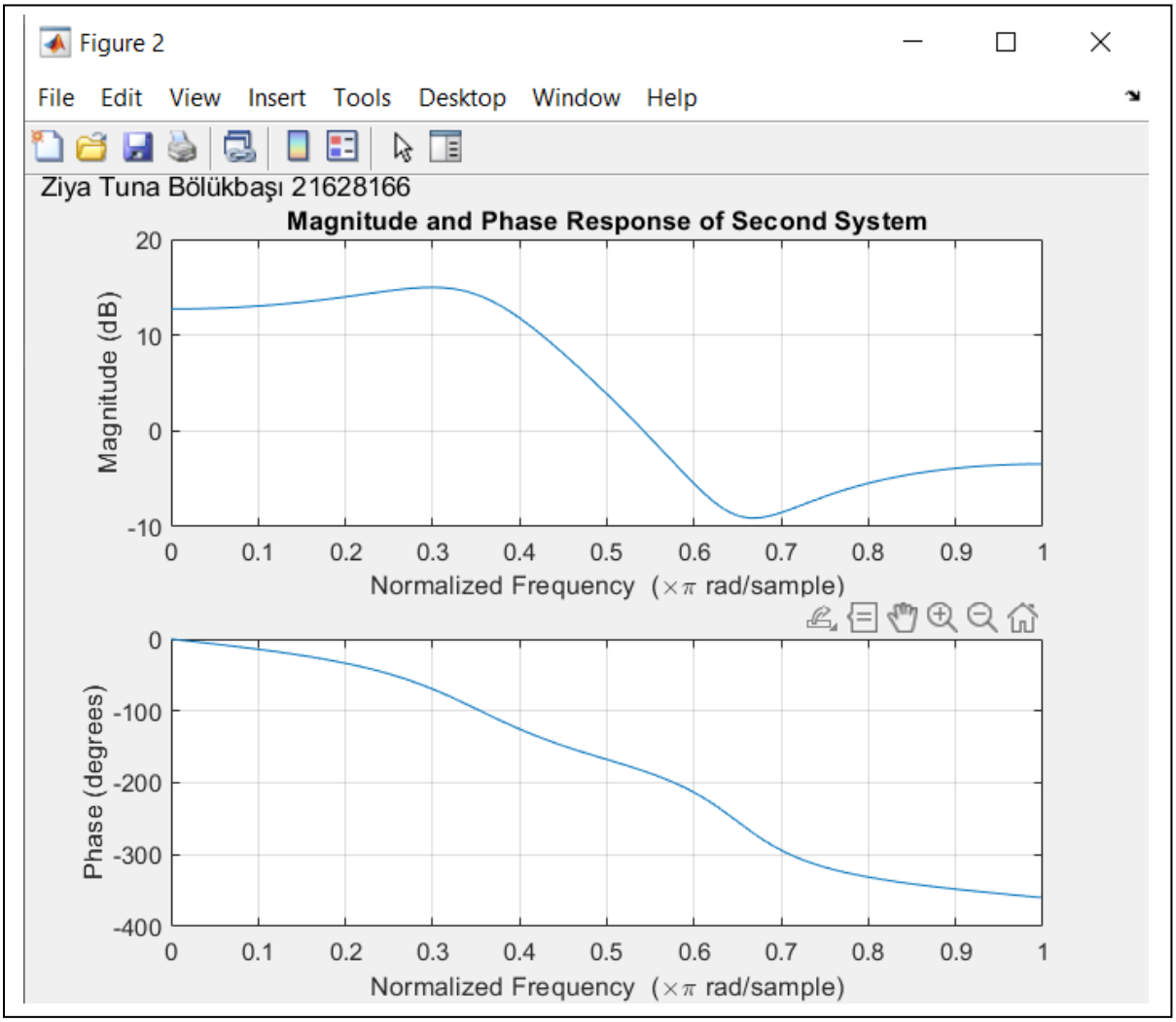
Third System is not stable for ROC does not contain unit circle . Also pole are in outside of unit circle So system is not Minimum Phase Systems.

9)

Matlab Code:

```
clc;
clear all;
close all;
num_a = [1 0.7264 0.64];
den_a = [1 -0.6356 0.49];
num_b =[1 1.135 1.5625];
den_b = [1 -0.6356 0.49];
figure; freqz(num_a,den_a);
title('Magnitude and Phase Response of First System');
gtext('Ziya Tuna Bölükbaşı 21628166');
figure; freqz(num_b,den_b);
title('Magnitude and Phase Response of Second System');
gtext('Ziya Tuna Bölükbaşı 21628166');
```





Second system's gain is greater than first system's gain.Because in second system vector's lentgh pointing to z is greater.First system is minimim phase system.Second system is not a minimum phase system since it's phase extends to minus infinity.