Tecnológico de Monterrey
Escuela de Ingeniería y Ciencias

1st Simulation Project

Control Engineering

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ITE

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Zapopan, Jalisco, México.

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General Parameters.

Date of Birth: May 10, 1999.

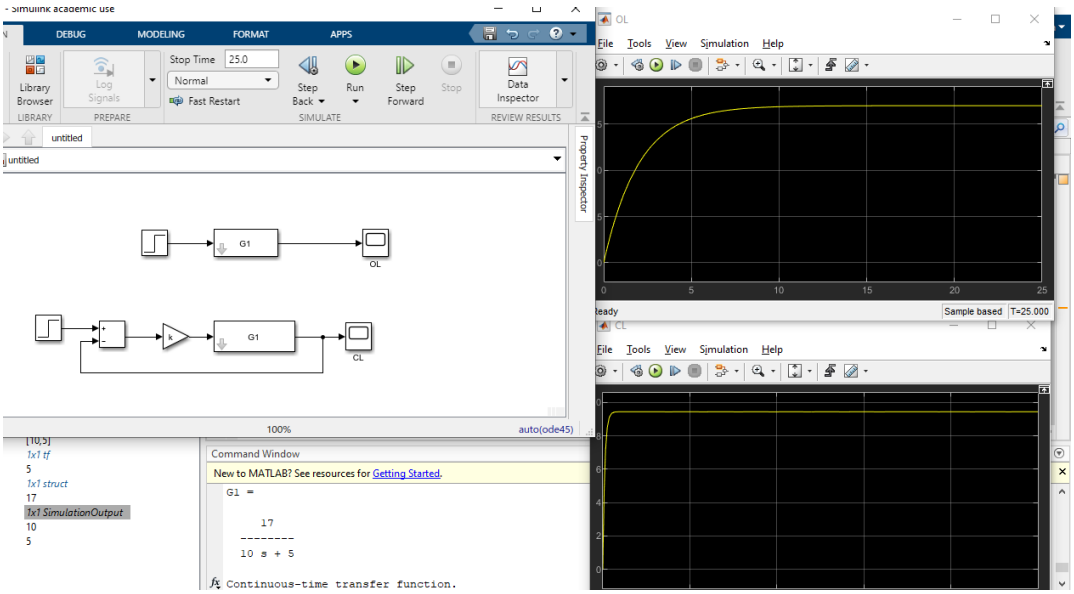
```
%General
a=10;
b=5;
c=17;
ut=a/2;
rt=a;
k=b;

matricula=struct;
matricula.general=struct;
matricula.P01=struct;
matricula.P02=struct;
matricula.P03=struct;
matricula.P04=struct;
matricula.P05=struct;
a00344428=matricula;

a00344428.general.a=a;
a00344428.general.b=b;
a00344428.general.c=c;

```

System 1

Code.

```

%Problema 1

num1=[c];
den1=[a b];
G1=tf(num1,den1);

%Open Loop P01
a00344428.P01.OL.tau=a/b;
a00344428.P01.OL.tss=5*a/b;
a00344428.P01.OL.yss=ut*c/b;

%Close Loop P01

a00344428.P01.CL.yss=rt*((k*c)/(b+k*c));
a00344428.P01.CL.tau=a/b;
a00344428.P01 CL.tss=5*a/b;
```

Simulink.



Transfer function.

$$\frac{17}{10\,s + 5}$$

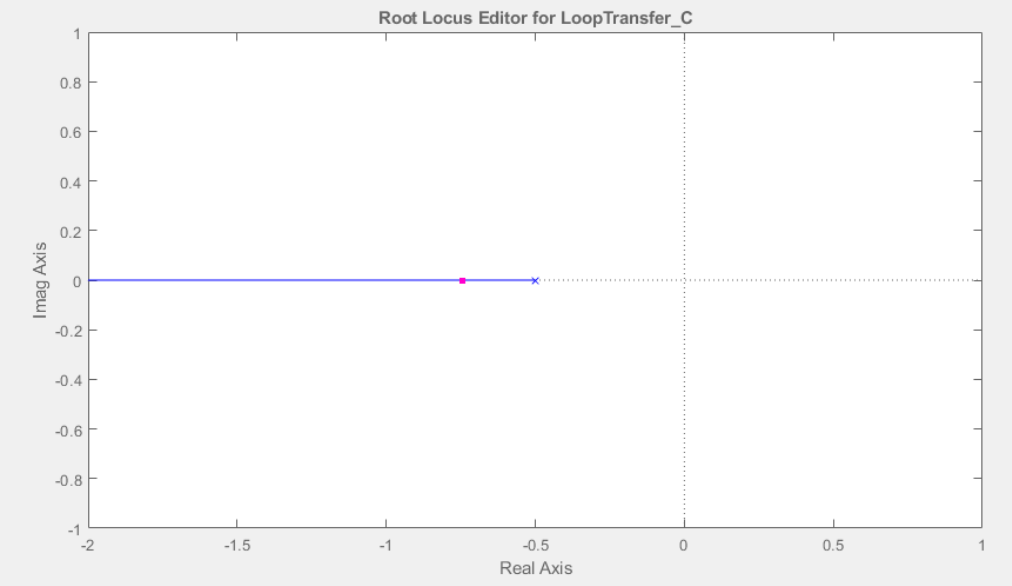
Characterization of the system in Open Loop.

```
>> a00344428.P01.OL.tau

ans =

     2

>> a00344428.P01.OL.tss

ans =

    10

>> a00344428.P01.OL.yss

ans =

    17
```

Characterization of the system in Close Loop

```
>> a00344428.P01.CL.yss

ans =

    9.4444

>> a00344428.P01.CL.tau

ans =

     2

>> a00344428.P01.CL.tss

ans =

    10
```

Gain range

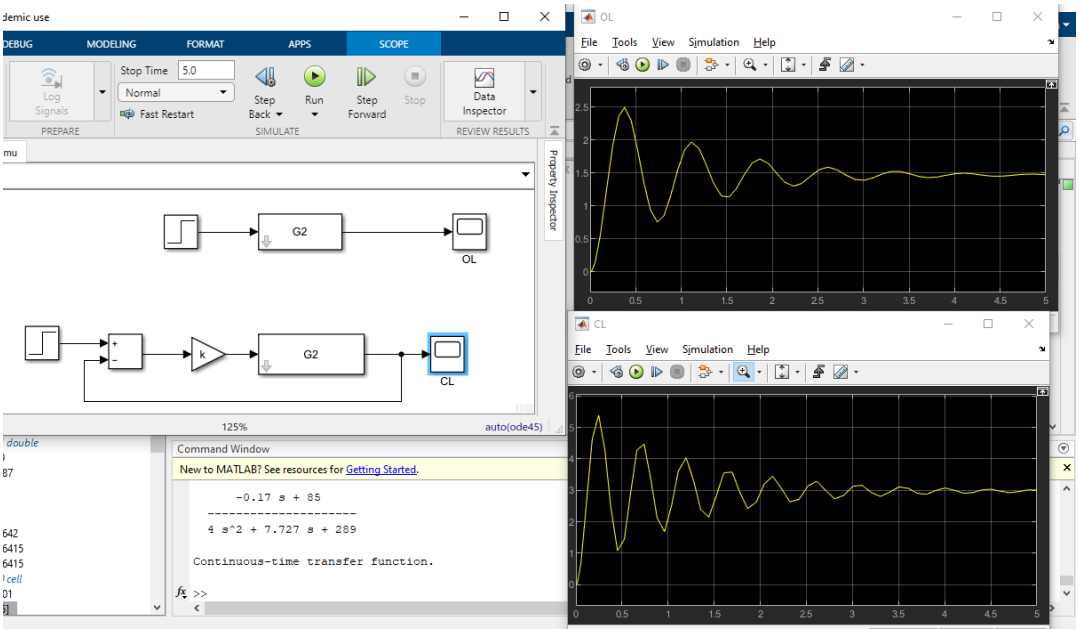


System 2.

Code.

```
%Problema 2
% e^(-0.004s) = -0.004s/2 + 1

num2 = [b*c*-0.004/2 b*c];
den2 = [4 c*a/22 c^2];
G2 = tf(num2,den2);


%Open Loop P02
a00344428.P02.OL.yss=ut*b*c/c^2;

a00344428.P02.OL.wn=sqrt(c^2/4);
a00344428.P02.OL.d=(c*a/22)/(2*4*a00344428.P02.OL.wn);
a00344428.P02.OL.wd=a00344428.P02.OL.wn*sqrt(1-(a00344428.P02.OL.d)^2);
a00344428.P02.OL.tss= 4/(a00344428.P02.OL.d*a00344428.P02.OL.wn);

%Close Loop P02
a00344428.P02.CL.yss = rt*((k*b*c)/(c^2+k*b*c));

a00344428.P02.CL.wn = sqrt((c^2+b*c*k)/4);
a00344428.P02.CL.d =((c*a/22)+(-0.004*b*c/2)*k)/(2*4*a00344428.P02.CL.wn);
a00344428.P02.CL.wd=a00344428.P02.CL.wn*sqrt(1-(a00344428.P02.CL.d)^2);
a00344428.P02.CL.tss= 4/(a00344428.P02.CL.d*a00344428.P02.CL.wn);
```

Simulink.



Transfer Function.

```
G2 =

      -0.17 s + 85
  ---------------------
  4 s^2 + 7.727 s + 289

Continuous-time transfer function.
```

Characterization of the system in Open Loop.

```
>> a00344428.P02.OL.yss

ans =

    1.4706

>> a00344428.P02.OL.wn

ans =

    8.5000

>> a00344428.P02.OL.d

ans =

    0.1136

>> a00344428.P02.OL.wd

ans =

    8.4449
```

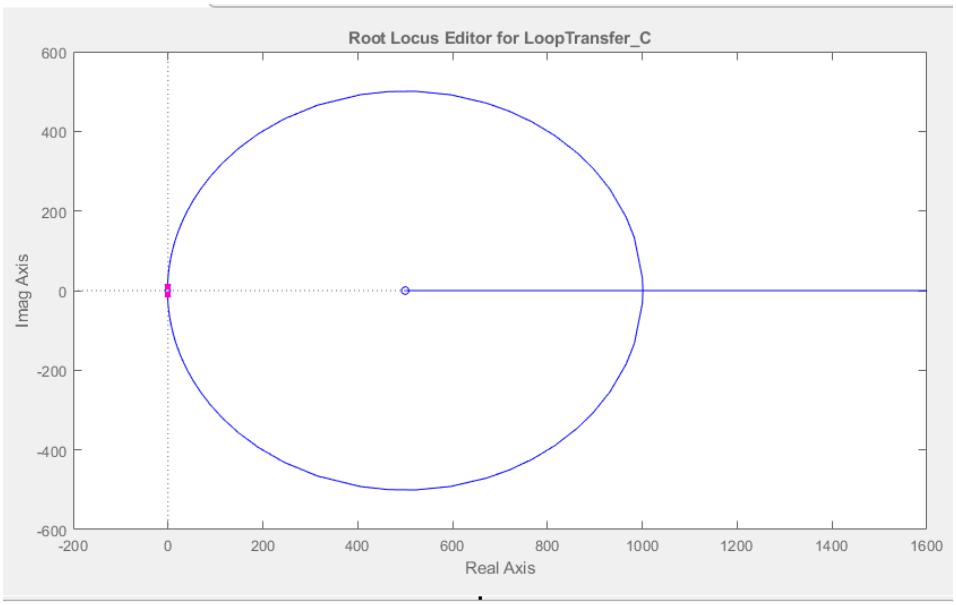
```
>> a00344428.P02.OL.tss

ans =

    4.1412
```

Characterization of the system in Open Loop.

```
>> a00344428.P02.CL.yss

ans =

    5.9524

>> a00344428.P02.CL.wn

ans =

   13.3604

>> a00344428.P02.CL.d

ans =

    0.0643

>> a00344428.P02.CL.wd

ans =

   13.3327
```

```
>> a00344428.P02.CL.tss

ans =

    4.6530
```

Gain range

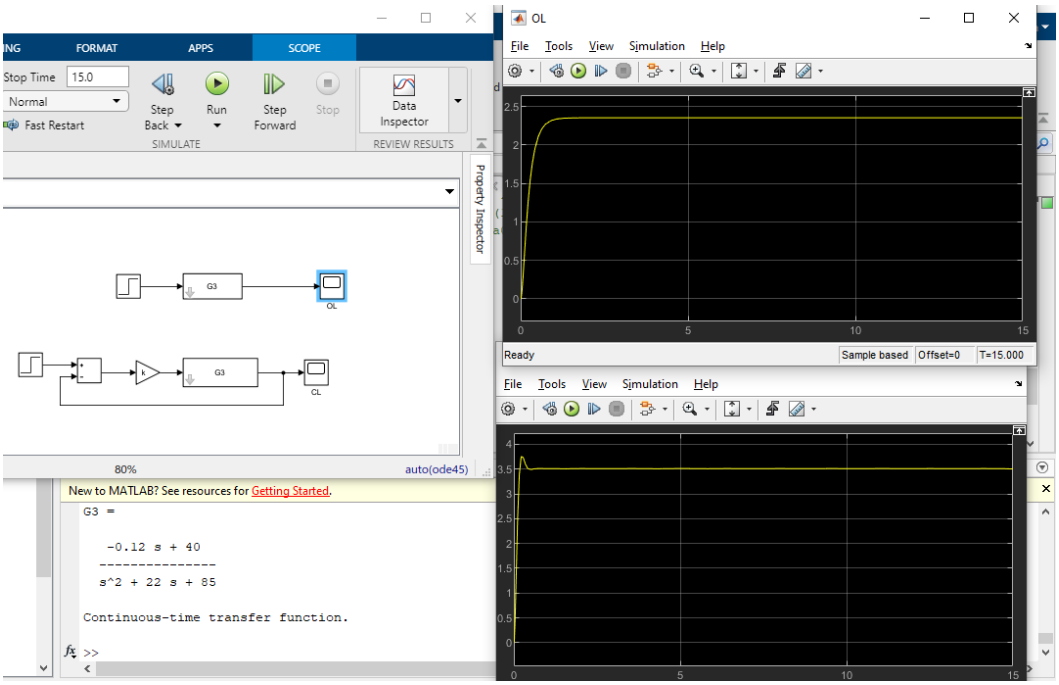


System 3.

Code.

```
%Problema 3
% e^(-0.006s) = -0.006s/2 + 1

num3 = [4*a*(-.006/2) 4*a];
den3 = [1 (b+c) b*c];
G3 = tf(num3,den3);

a00344428.P03.num=num3;
a00344428.P03.den=den3;

%Open Loop P03
a00344428.P03.OL.yss=ut*4*a/(b*c);

a00344428.P03.OL.wn=sqrt(b*c);
a00344428.P03.OL.d=(b+c)/(2*a00344428.P03.OL.wn);
a00344428.P03.OL.wd=a00344428.P03.OL.wn*sqrt(1-(a00344428.P03.OL.d)^2);
a00344428.P03.OL.tss=4/(a00344428.P03.OL.d*a00344428.P03.OL.wn);

%Close Loop P03
a00344428.P03.CL.yss=rt*4*a*k/(b*c+4*a*k);

a00344428.P03.CL.wn=sqrt(b*c + 4*a*k);
a00344428.P03.CL.d=(b+c+(-0.006*4*a*k/2))/(2*a00344428.P03.CL.wn);
a00344428.P03.CL.wd=a00344428.P03.CL.wn*sqrt(1-(a00344428.P03.CL.d)^2);
a00344428.P03.CL.tss=4/(a00344428.P03.CL.d*a00344428.P03.CL.wn);
```

Simulink.



Transfer Function:

```
G3 =

   -0.12 s + 40
  ---------------
  s^2 + 22 s + 85
```

Characterization of the system in Open Loop.

```
>> a00344428.P03.OL.yss

ans =

    2.3529

>> a00344428.P03.OL.wn

ans =

    9.2195

>> a00344428.P03.OL.d

ans =

    1.1931

>> a00344428.P03.OL.wd

ans =

   0.0000 + 6.0000i
```

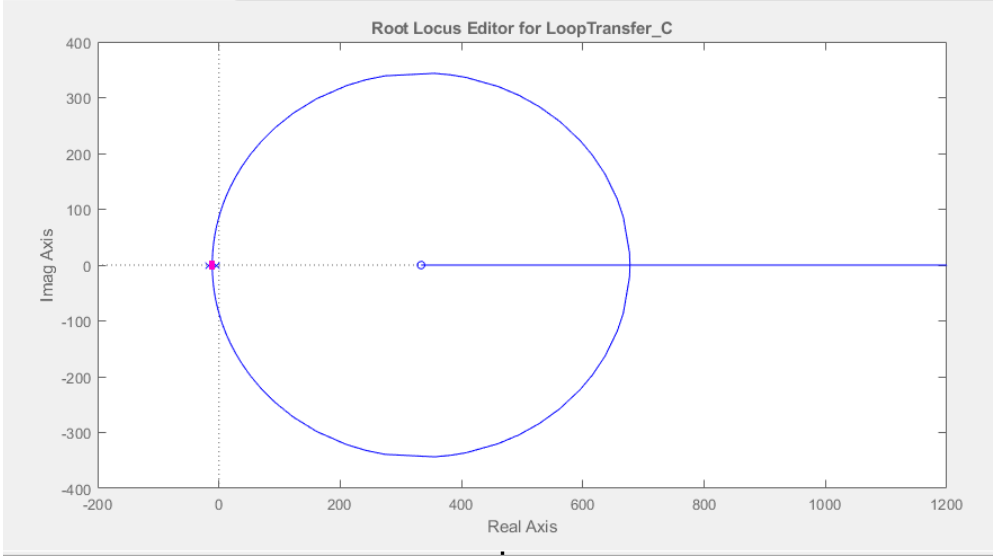
```
>> a00344428.P03.OL.tss

ans =

    0.3636
```

Characterization of the system in Close Loop

```
>> a00344428.P03.CL.yss

ans =

    7.0175

>> a00344428.P03.CL.wn

ans =

   16.8819

>> a00344428.P03.CL.d

ans =

    0.6338

>> a00344428.P03.CL.wd

ans =

   13.0579
```

```
>> a00344428.P03.CL.tss

ans =

    0.3738
```

Gain range.

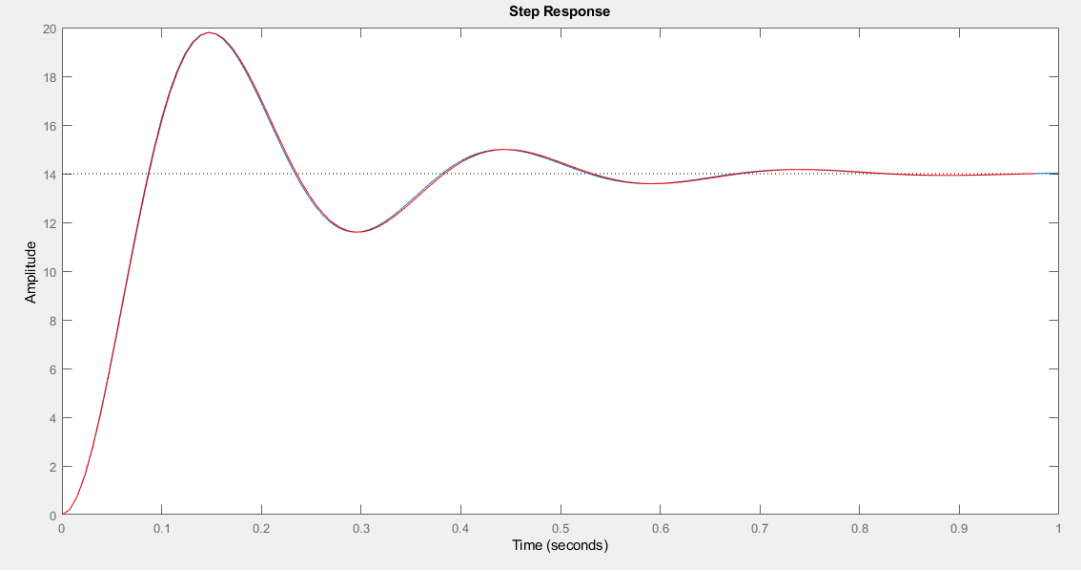


System 4

Code for identification Second Order.

```
%Using the array from DataID (given for the project)
MV = DataID{2};
t = MV(:,1);
y = MV(:,2);

%k = last value in array from y axis
k = y(end,:);

%Output of system when -> t = 5T
T = (k*0.9933);

my = max(y);
mp = (my-k)/k;

w = -log(mp)/pi;
delta = sqrt((w*w)/(1+(w*w)));

Fnd = find(y == my);
tp = t(Fnd);

%Finding the damped natural frequency
wd = pi/tp;

%Finding the damping factor
wn = wd/sqrt(1-(delta*delta));
```

Graph from the result of the identification.



Transfer function and values.

```
G =

          6869
  ---------------------
  s^2 + 11.96 s + 490.6

Continuous-time transfer function.
```

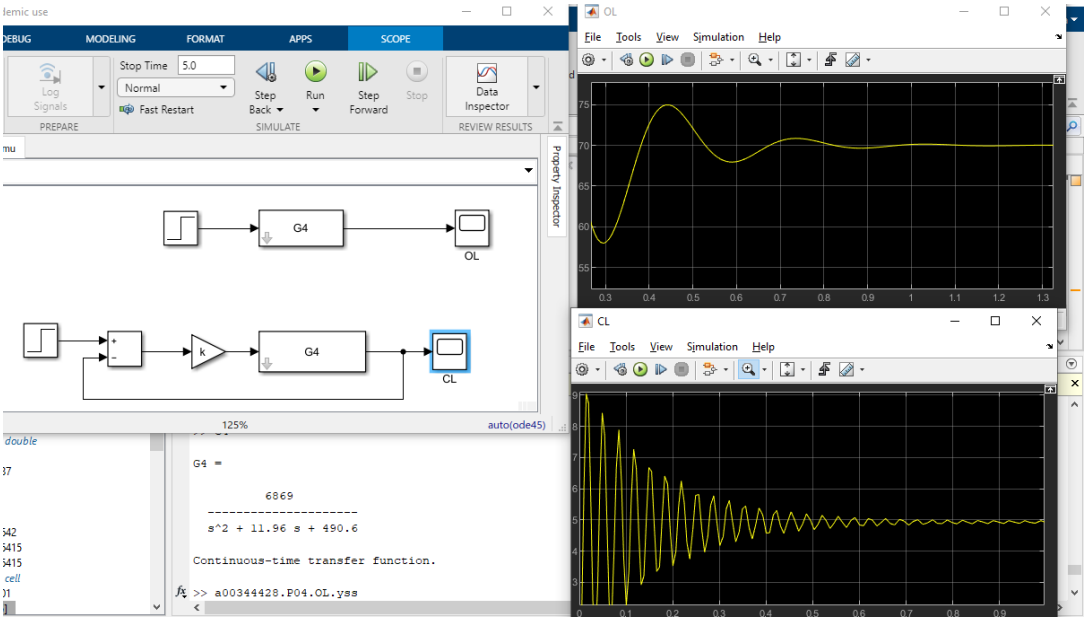
```
>> b

b =

     1

>> c

c =

   11.9642

>> d

d =

  490.6415
```

Code:

```
90      %Problema 4
91      %Identificacion DataID{2}
92      %6869/(s^2 + 11.9642s + 490.6415)
93      %a/(bs^2 +cs + d)
94 -    a4=6869;
95 -    b4=1;
96 -    c4=11.9642;
97 -    d4=490.6415;
98
99 -    num4 = [a4];
100 -   den4 = [b4 c4 d4];
101 -   G4 = tf(num4,den4);
102
103 -   a00344428.P04.num=num4;
104 -   a00344428.P04.den=den4;
105
106     %Open Loop
107 -   a00344428.P04.OL.yss=ut*a4/(d4);
108
109 -   a00344428.P04.OL.wn=sqrt(d4);
110 -   a00344428.P04.OL.d=c4/(2*a00344428.P04.OL.wn);
111 -   a00344428.P04.OL.wd = a00344428.P04.OL.wn*sqrt(1-(a00344428.P04.OL.d)^2);
112 -   a00344428.P04.OL.tss=4/(a00344428.P1OL.d*a00344428.P04.OL.wn);
113
```

```
%Close Loop
a00344428.P04.CL.yss=rt*a4*k/(d4+a4*k);

a00344428.P04.CL.wn=sqrt(d4 + a4*k);
a00344428.P04.CL.d=c4/(2*a00344428.P04.CL.wn);
a00344428.P04.CL.wd=a00344428.P04.CL.wn*sqrt(1-(a00344428.P04.CL.d)^2);
a00344428.P04.CL.tss=4/(a00344428.P04.CL.d*a00344428.P04.CL.wn);
```

Simulink.



Transfer function.

```
G4 =

          6869
  --------------------
  s^2 + 11.96 s + 490.6
```

Characterization of the system in Open Loop.

```
>> a00344428.P04.OL.yss

ans =

   70.0002

>> a00344428.P04.OL.wn

ans =

   22.1504

>> a00344428.P04.OL.d

ans =

    0.2701

>> a00344428.P04.OL.wd

ans =

   21.3274
```

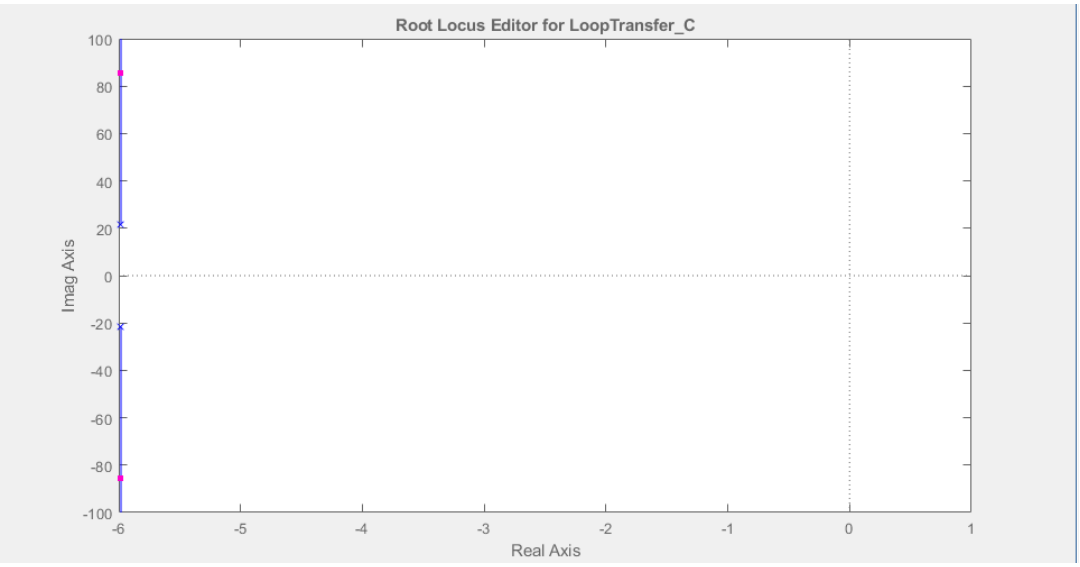
```
>> a00344428.P04.OL.tss

ans =

    0.6687
```

Characterization of the system in Close Loop.

```
>> a00344428.P04.CL.yss

ans =

    9.8592

>> a00344428.P04.CL.wn

ans =

  186.6431

>> a00344428.P04.CL.d

ans =

    0.0321

>> a00344428.P04.CL.wd

ans =

  186.5472
```

```
>> a00344428.P04.CL.tss

ans =

    0.6687
```

Gain range.



System 5

General:

```
%Problema 5
Q1 = Qin_1(2);
H1Max = H1max(2);
A01 = A1(2);
R01 = R1(2);

Q2 = Qin_2(2);
H2Max = H2max(2);
A02 = A2(2);
R02 = R2(2);
```

1.

```
%1.
%   H1(s)/Qin(s)= ?
%   From the book we know that: (R1Cs + 1)H(s)=R1Qin(s) where C = A1
%   Therefore: H1(s)/Qin(s) = R1/(R1A1s + 1)
num1 = [R01];
den1 = [(R01*A01) 1];

%   H2(s)/ Qin(s) = ?
%   From the equation above, we obtain H2(s) = R2, however, since now the
%   Qin is the multiplication of the 1st tank and the 2nd tank
%   Qin(s) = (R1A1s + 1)(R2A2s + 1) = (R1A1R2A2)s^2 + (R1A1+R2A2)s + 1
%   Therefore: H2(s)/ Qin(s) = R2/(R1A1R2A2)s^2 + (R1A1+R2A2)s + 1
num2 = [R02];
den2 = [(R01*A01*R02*A02) (R01*A01 + R02*A02) 1]
```

2.

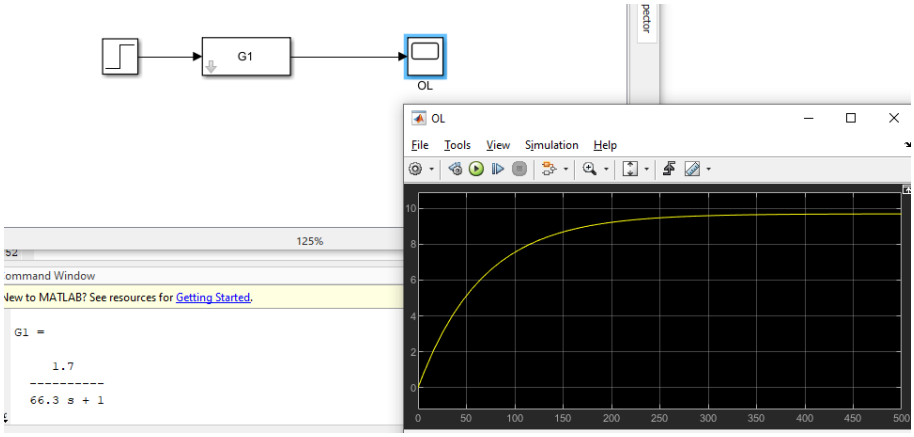
```
%2
%   H1(s)/Qin(s)= ?
G1 = tf(num1, den1);
%   H2(s)/ Qin(s) = ?
G2 = tf(num2, den2);
```

```
G1 =

    1.7
  ----------
  66.3 s + 1

Continuous-time transfer function.

>> G2

G2 =

             4
  --------------------------
  1.724e04 s^2 + 326.3 s + 1

Continuous-time transfer function.
```

3.

```
%3
a00344428.P05.H1.yss= Qin1*R01;
a00344428.P05.H1.tss= 5*R01*A01;
```

```
>> G1

G1 =

     1.7
  ----------
  66.3 s + 1

Continuous-time transfer function.

>> a00344428.P05.H1.yss

ans =

    9.6900

>> a00344428.P05.H1.tss

ans =

  331.5000
```



4.

```
%4
a00344428.P05.H2.yss= Qin2*R02;

a00344428.P05.H2.wn=sqrt(1/(R01*A01*R02*A02));
a00344428.P05.H2.d=(R01*A01 + R02*A02)/(2*R01*A01*R02*A02*a00344428.P05.H2.wn);
a00344428.P05.H2.wd=a00344428.P05.H2.wn*sqrt(1-(a00344428.P05.H2.d)^2);
a00344428.P05.H2.tss=4/(a00344428.P05.H2.d*a00344428.P05.H2.wn);
```

```
G2 =

             4
  --------------------------
  1.724e04 s^2 + 326.3 s + 1

Continuous-time transfer function.

>> a00344428.P05.H2.yss

ans =

   12.4000

>> a00344428.P05.H2.d

ans =

    1.2426

>> a00344428.P05.H2.wn

ans =

    0.0076
```

```
>> a00344428.P05.H2.wd

ans =

   0.0000 + 0.0056i

>> a00344428.P05.H2.tss

ans =

  422.6295
```