```
% Open Loop system characterization, identification and
 representation.
% 1. State Space Representation
% 2. Transfer Function of Open Loop System
% 3. O.C.F, C.C.F, J.C.F.
% 4. Impulse Response & Step Response
% 5. Bode Plot & Root Locus

% 1. State Space Representation
% SISO, Location #1, Linearized Actuator, Linearized Sensor
% p.133 3a)
A = [0 1; 0 0];
B = [0; 826];
C = [1 0];

% Create state-space model
ss_ol = ss(A,B,C,0);

% 2. Transfer Function of Open Loop System
% Convert state-space representation to transfer function
[num,denom]= ss2tf(A,B,C,0)
tf_ol = tf(num,denom)

% Find poles of open-loop system
% by finding the eigenvalues of the
% system matrix A. These poles are
% equal to the poles of the transfer
% function, and determine stability.
% det(sI - A) = 0
poles = eig(A)

% 3. O.C.F, C.C.F, J.C.F.
% OCF
% Compute the observability matrix
Ox = obsv(A,C)
% Determine the number of unobservable states
nUnobservableStates = length(A)-rank(Ox)

% Determine characteristic polynomial
syms x
CP = charpoly(A,x)

% Observable Canonical Form
Ao = [0 0; 1 0]
Co = [0 1]

Oxo = obsv(Ao, Co)
Toinv = inv(Oxo) * Ox
Bo = Toinv * B
To = inv(Toinv)

% Check equality
```

```
Ao
Toinv * A * To

% Observable Forms in State Space Representation
ss_ol_obs = ss(Ao,Bo,Co,0)

%C.C.F
% Compute the controllability matrix
Cx = ctrb(A,B)
% Determine the number of uncontrollable states
unco = length(A) - rank(Cx)

% Controllable Canonical Form
Ac = Ao.'
Bc = Co.'

Cxc = ctrb(Ac, Bc)
Tcinv = inv(Cxc) * Cx

Tc = inv(Tcinv)
Cc = C * Tc

% Check equality
Ac
Tcinv * A * Tc
isequal(Ac,Tcinv * A * Tc)

% Controllable Forms in State Space Representation
ss_ol_ctrl = ss(Ac,Bc,Cc,0)

% Create Jordan form of matrix A
JA = jordan(A)

% 4. Impulse Response & Step Response
% Impulse Response
figure (1)
subplot(2,1,1)
impulse(ss_ol)
title('Impulse Reponse of Open-Loop Linearized Magnetic Levitation
 System');

% Step Response
subplot(2,1,2)
step(ss_ol)
title('Step Reponse of Open-Loop Linearized Magnetic Levitation
 System');


% 5. Bode Plot & Root Locus
% Bode Plot
figure (2)
subplot(2,1,1)
bodeplot(ss_ol)
title('Bode Plot of Open-Loop Linearized Magnetic Levitation System');
```

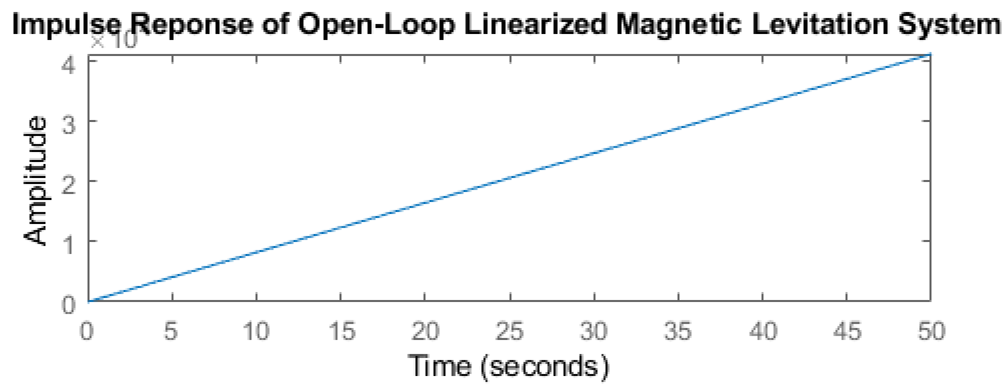
```
% Root Locus
subplot(2,1,2)
rlocusplot(ss_ol)
title('Root Locus of Open-Loop Linearized Magnetic Levitation
 System');
```

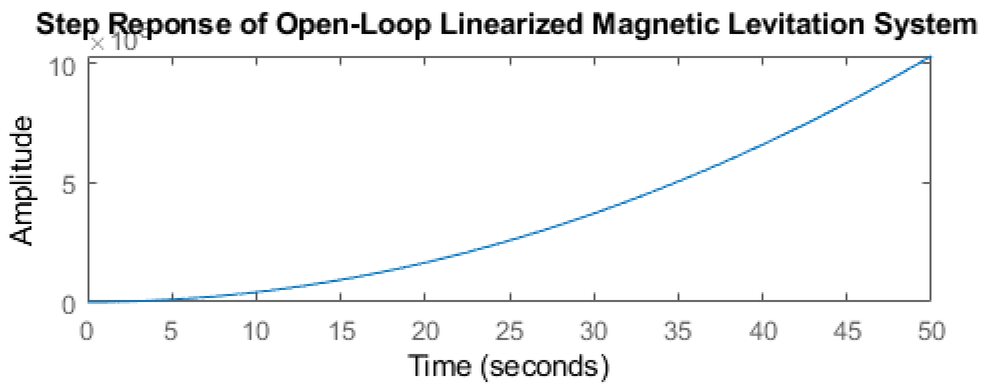
```
num =

     0     0   826


denom =

     1     0     0


tf_ol =

  826
  ---
  s^2

Continuous-time transfer function.


poles =

     0
     0


Ox =

     1     0
     0     1


nUnobservableStates =

     0


CP =

x^2


Ao =

     0     0
     1     0
```

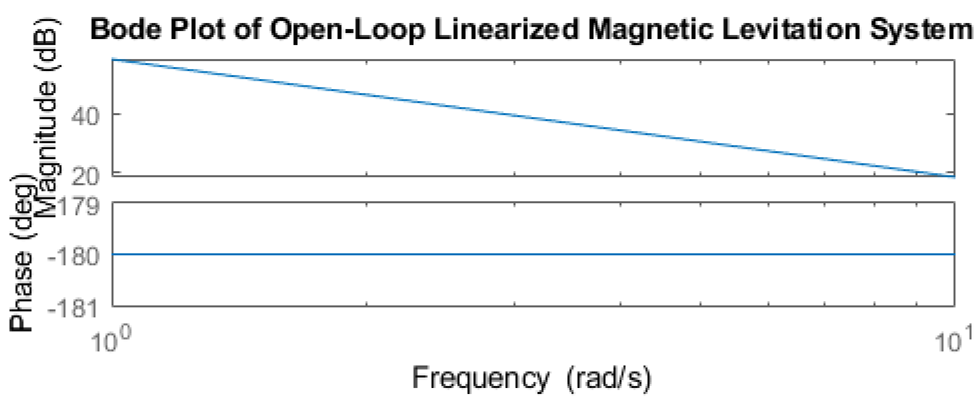
```
Co =

     0     1


Oxo =

     0     1
     1     0


Toinv =

     0     1
     1     0


Bo =

   826
     0


To =

     0     1
     1     0


Ao =

     0     0
     1     0


ans =

     0     0
     1     0


ss_ol_obs =

  A =
        x1  x2
   x1    0   0
   x2    1   0

  B =
         u1
   x1   826
   x2     0
```

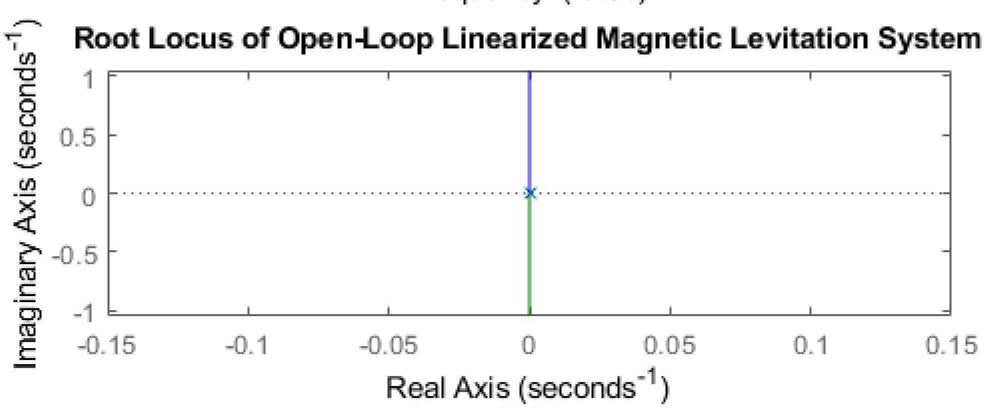
```
  C =
       x1  x2
   y1   0   1

  D =
       u1
   y1   0

Continuous-time state-space model.


Cx =

     0   826
   826     0


unco =

     0


Ac =

     0     1
     0     0


Bc =

     0
     1


Cxc =

     0     1
     1     0


Tcinv =

   826     0
     0   826


Tc =

    0.0012         0
         0    0.0012


Cc =
```

```
    0.0012         0


Ac =

     0     1
     0     0


ans =

     0     1
     0     0


ans =

  logical

   1


ss_ol_ctrl =

  A =
       x1  x2
   x1   0   1
   x2   0   0

  B =
       u1
   x1   0
   x2   1

  C =
             x1        x2
   y1  0.001211         0

  D =
       u1
   y1   0

Continuous-time state-space model.


JA =

     0     1
     0     0
```


Impulse Reponse of Open-Loop Linearized Magnetic Levitation System
Amplitude
Time (seconds)
0
1
2
3
4
0
5
10
15
20
25
30
35
40
45
50


Step Reponse of Open-Loop Linearized Magnetic Levitation System
Amplitude
Time (seconds)
0
5
10
0
5
10
15
20
25
30
35
40
45
50


Bode Plot of Open-Loop Linearized Magnetic Levitation System
Magnitude (dB)
Phase (deg)
20
40
-179
-180
-181
10^0
10^1
Frequency (rad/s)


Root Locus of Open-Loop Linearized Magnetic Levitation System
Imaginary Axis (seconds^-1)
Real Axis (seconds^-1)
1
0.5
0
-0.5
-1
-0.15
-0.1
-0.05
0
0.05
0.1
0.15

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