ES155 P7

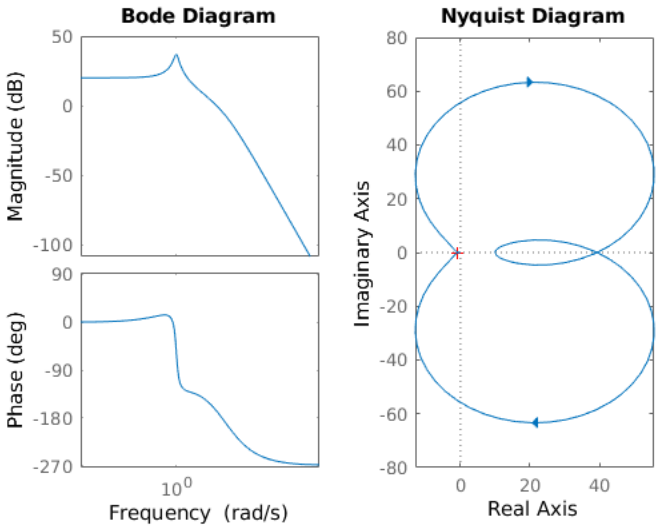
Contents

Problem 3

3.a

```
P = tf(1, [1 10 3 10])
S = 1000 * tf([1 1], [1 10])

L = P*S

figure(1); clf;
subplot(1,2,1)
bode(L)
subplot(1,2,2)
nyquist(L)

saveas(gcf, "ES155P7_3a.jpg")

pole(L)
[GainMargin, PhaseMargin, Wcg, Wcp] = margin(L)
```

```
P =

             1
  -----------------------
  s^3 + 10 s^2 + 3 s + 10

Continuous-time transfer function.


S =

  1000 s + 1000
  -------------
     s + 10

Continuous-time transfer function.


L =

              1000 s + 1000
  ----------------------------------
  s^4 + 20 s^3 + 103 s^2 + 40 s + 100

Continuous-time transfer function.


ans =

 -10.0000 + 0.0000i
  -9.7980 + 0.0000i
  -0.1010 + 1.0052i
  -0.1010 - 1.0052i


GainMargin =

    1.6047


PhaseMargin =

   12.9616


Wcg =

    9.0682


Wcp =

    7.0090
```

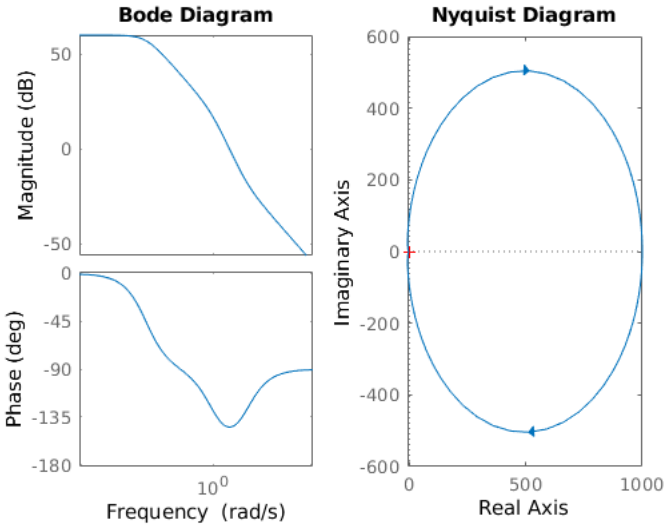


3.b

```
P = tf(100, [100, 101, 1])
S = tf([1 10], 1)

L = P*S

figure(2); clf;
subplot(1,2,1)
bode(L)
subplot(1,2,2)
nyquist(L)

saveas(gcf, "ES155P7_3b.jpg")

pole(L)
[GainMargin, PhaseMargin, Wcg, Wcp] = margin(L)
```

```
P =

          100
  -------------------
  100 s^2 + 101 s + 1

Continuous-time transfer function.


S =

  s + 10

Continuous-time transfer function.


L =

     100 s + 1000
  -------------------
  100 s^2 + 101 s + 1

Continuous-time transfer function.


ans =

   -1.0000
   -0.0100


GainMargin =

   Inf


PhaseMargin =

   35.2780


Wcg =

   NaN
```

```
Wcp =

    3.1623
```



Problem 4

```
% Constants
a = 0.2
b = 25
c = 50
T = 200
m = 1000

P = tf(T*b*a, [m, a*m + c, a*c])
```

```
a =

    0.2000

b =

    25

c =

    50

T =

   200

m =

        1000

P =

          1000
  ---------------------
  1000 s^2 + 250 s + 10

Continuous-time transfer function.
```

4.a

```
table = zeros(4,8);

figure(3); clf;
figure(4); clf;

Kp = [0.5, 0.05, 0.05, 0.005]
```

```
Ki = [0.1, 1, 0.001, 0.001]

for i = 1:4
   figure(3)
   kp = Kp(i)
   ki = Ki(i)

   table(i,1) = kp;
   table(i,2) = ki;

   C = tf([kp, ki], 1)
   G = feedback(P*C, 1)

   L = P*C
   sysL = ss(L)

   sys = ss(G);

   table(i,3) = isstable(sys);

   [GainMargin, PhaseMargin, Wcg, Wcp] = margin(sysL)

   table(i,4) = GainMargin;
   table(i,5) = PhaseMargin;

   [y, t] = step(sys);
   if y(length(t)) == y(length(t-2))
       error_SS = 1 - y(length(t))
   else
       error("Steady State not reached")
   end

   table(i,6) = error_SS;

   S = stepinfo(sys)

   table(i,7) = S.RiseTime;
   table(i,8) = S.Overshoot;

   subplot(2,4,i)
   pzmap(sys)

   subplot(2,4,i+4)
   step(sys, S.RiseTime*10)

   figure(4)
   subplot(2,4,i)
   bode(sys)
   subplot(2,4,i+4)
   nyquist(sys)

   % plot the unit circle on the nyquist plot
   theta = 0:0.1:2*pi;
   x = cos(theta);
   y = sin(theta);
   hold on;
   plot(x,y,'--');
   hold off;
end

table
```

```
Kp =

    0.5000    0.0500    0.0500    0.0050


Ki =

    0.1000    1.0000    0.0010    0.0010


kp =

    0.5000


ki =

    0.1000


C =

  0.5 s + 0.1

Continuous-time transfer function.


G =
```

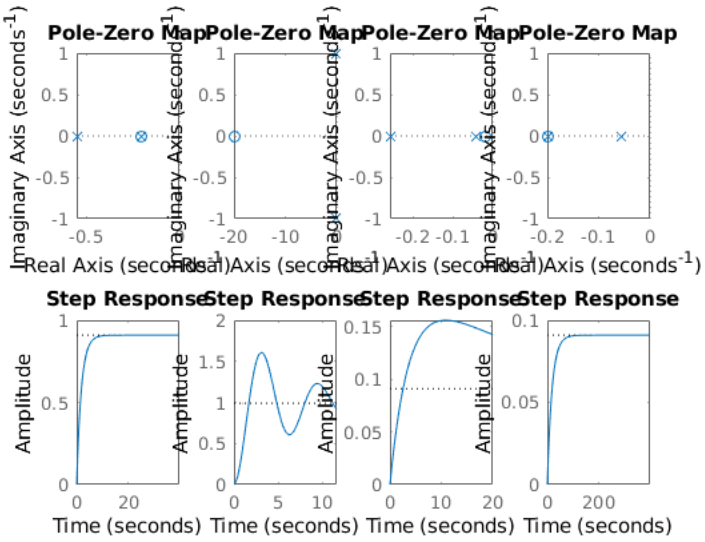
```
       500 s + 100
  ----------------------
  1000 s^2 + 750 s + 110

Continuous-time transfer function.


L =

       500 s + 100
  ---------------------
  1000 s^2 + 250 s + 10

Continuous-time transfer function.


sysL =

  A =
         x1     x2
   x1  -0.25  -0.08
   x2  0.125      0

  B =
       u1
   x1   1
   x2   0

  C =
        x1   x2
   y1  0.5  0.8

  D =
       u1
   y1   0

Continuous-time state-space model.


GainMargin =

   Inf


PhaseMargin =

   95.7406


Wcg =

   NaN


Wcp =

    0.4974


error_SS =

    0.0910


S =

  struct with fields:

        RiseTime: 3.9946
    SettlingTime: 7.1129
     SettlingMin: 0.8223
     SettlingMax: 0.9091
       Overshoot: 0
      Undershoot: 0
            Peak: 0.9091
        PeakTime: 19.1743


kp =

    0.0500


ki =

     1


C =
```

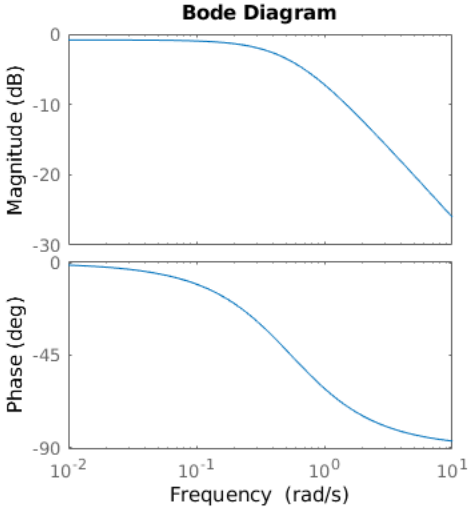
```
  0.05 s + 1

Continuous-time transfer function.


G =

       50 s + 1000
  ----------------------
  1000 s^2 + 300 s + 1010

Continuous-time transfer function.


L =

      50 s + 1000
  --------------------
  1000 s^2 + 250 s + 10

Continuous-time transfer function.


sysL =

  A =
         x1     x2
   x1  -0.25  -0.08
   x2  0.125      0

  B =
       u1
   x1   4
   x2   0

  C =
          x1      x2
   y1  0.0125       2

  D =
       u1
   y1   0

Continuous-time state-space model.


GainMargin =

   Inf


PhaseMargin =

   17.1460


Wcg =

   NaN


Wcp =

    0.9900


error_SS =

    0.0047


S =

  struct with fields:

        RiseTime: 1.1611
    SettlingTime: 25.7136
     SettlingMin: 0.6095
     SettlingMax: 1.6066
       Overshoot: 62.2638
      Undershoot: 0
            Peak: 1.6066
        PeakTime: 3.0701


kp =

    0.0500


ki =
```

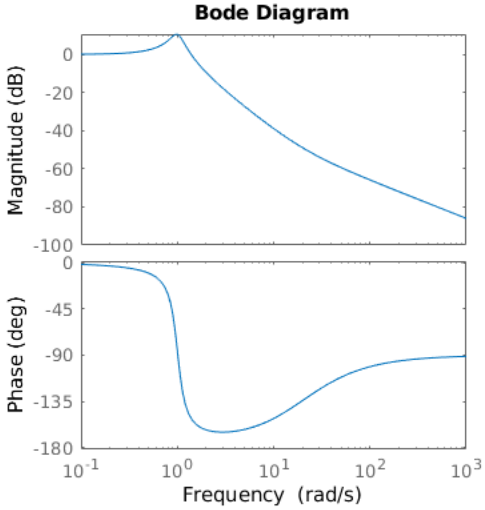
```
   1.0000e-03


C =

  0.05 s + 0.001

Continuous-time transfer function.


G =

        50 s + 1
  ---------------------
  1000 s^2 + 300 s + 11

Continuous-time transfer function.


L =

        50 s + 1
  ---------------------
  1000 s^2 + 250 s + 10

Continuous-time transfer function.


sysL =

  A =
         x1     x2
   x1  -0.25  -0.08
   x2  0.125      0

  B =
        u1
   x1  0.25
   x2     0

  C =
         x1     x2
   y1    0.2  0.032

  D =
       u1
   y1   0

Continuous-time state-space model.


GainMargin =

   Inf


PhaseMargin =

   Inf


Wcg =

   NaN


Wcp =

   NaN


error_SS =

    0.9089


S =

  struct with fields:

        RiseTime: 2.0130
    SettlingTime: 98.7607
     SettlingMin: 0.0896
     SettlingMax: 0.1557
       Overshoot: 71.3097
      Undershoot: 0
            Peak: 0.1557
        PeakTime: 11.0995
```

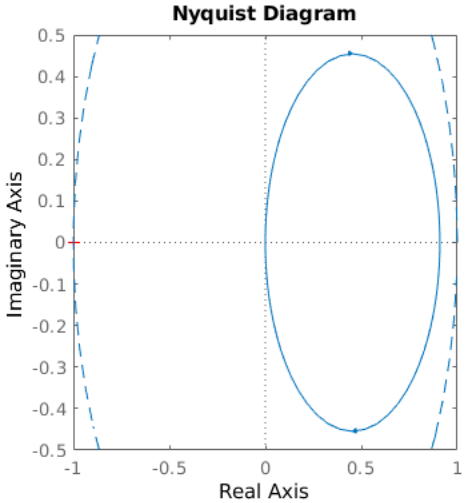
```
kp =

    0.0050


ki =

   1.0000e-03


C =

  0.005 s + 0.001

Continuous-time transfer function.


G =

         5 s + 1
  --------------------
  1000 s^2 + 255 s + 11

Continuous-time transfer function.


L =

         5 s + 1
  --------------------
  1000 s^2 + 250 s + 10

Continuous-time transfer function.


sysL =

  A =
         x1     x2
   x1  -0.25  -0.08
   x2  0.125      0

  B =
         u1
   x1  0.125
   x2      0

  C =
         x1     x2
   y1   0.04  0.064

  D =
       u1
   y1   0

Continuous-time state-space model.


GainMargin =

   Inf


PhaseMargin =

   Inf


Wcg =

   NaN


Wcp =

   NaN


error_SS =

    0.9091


S =

  struct with fields:

        RiseTime: 39.9456
    SettlingTime: 71.1286
     SettlingMin: 0.0822
     SettlingMax: 0.0909
```

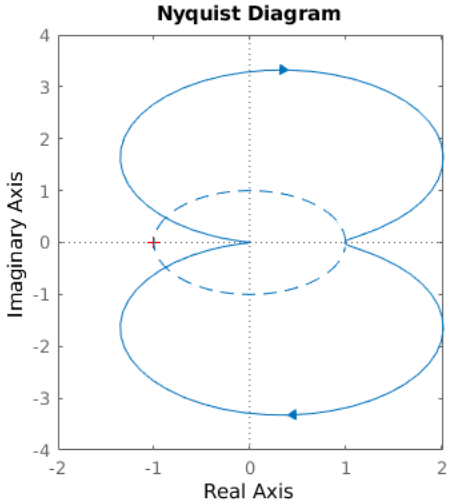
```
          Overshoot: 0
         Undershoot: 0
               Peak: 0.0909
           PeakTime: 191.7425


    table =

      Columns 1 through 7

        0.5000    0.1000    1.0000       Inf   95.7406    0.0910    3.9946
        0.0500    1.0000    1.0000       Inf   17.1460    0.0047    1.1611
        0.0500    0.0010    1.0000       Inf       Inf    0.9089    2.0130
        0.0050    0.0010    1.0000       Inf       Inf    0.9091   39.9456

      Column 8

             0
        62.2638
        71.3097
             0
```


Pole-Zero Map
Pole-Zero Map
Pole-Zero Map
Pole-Zero Map
Imaginary Axis (seconds-1)
Real Axis (seconds-1)
Step Response
Step Response
Step Response
Step Response
Amplitude
Time (seconds)


Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/s)


Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/s)


Nyquist Diagram
Imaginary Axis
Real Axis


Nyquist Diagram
Imaginary Axis
Real Axis

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