enae432 hw09

Table of Contents

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problem 1

```
I  = 5;
b  = 1;
Km = 3;

s  = tf('s');
G = Km/(I*s + b);
% part a

K_test = 1;

H_0 = K_test;
L_0 = H_0*G;
T_0 = feedback(L_0, 1)
disp(pole(T_0))
% part b

t_s_des = 2;
omega_d = 50;

sigma_desired = 4/t_s_des
K = (I*sigma_desired - 1)/Km

H = K;
L = H*G;
T = feedback(L, 1)
disp(stepinfo(T))

y_ss = dcgain(T) * omega_d
e_ss = omega_d - y_ss
```

```
T_0 =

     3
  -------
  5 s + 4

Continuous-time transfer function.
   -0.8000


sigma_desired =

     2


K =

     3


T =

     9
  --------
  5 s + 10

Continuous-time transfer function.
         RiseTime: 1.0985
    TransientTime: 1.9560
     SettlingTime: 1.9560
      SettlingMin: 0.8141
      SettlingMax: 0.8994
        Overshoot: 0
       Undershoot: 0
             Peak: 0.8994
         PeakTime: 3.6611


y_ss =

    45


e_ss =

     5
```

part c

```
syms Kp_sym Ki_sym s_sym
```

```
G_sym = Km/(I*s_sym + b);
H_sym = (Kp_sym*s_sym + Ki_sym)/s_sym;
L_sym = H_sym * G_sym;
T_sym = L_sym/(1 + L_sym);

dc_gain = limit(T_sym, s_sym, inf)
```

```
dc_gain =

0
```

part e

```
Ki = 20/3;
Kp = 19/3;

H = pid(Kp, Ki);
L = H*G;
T = feedback(L, 1);
disp(stepinfo(T))
```

```
        RiseTime: 0.3981
   TransientTime: 2.6099
    SettlingTime: 2.6099
     SettlingMin: 0.9044
     SettlingMax: 1.1090
       Overshoot: 10.8989
      Undershoot: 0
            Peak: 1.1090
        PeakTime: 1.0600
```

problem 2

```
s  = tf('s');
G = 10/(s*(s+4)^2);

[Gm, Pm, Omegacg, Omegacp] = margin(G)

Ku = Gm
Tu = 2*pi/Omegacp

Kp = 3/5*Ku;
Ki = 2*Kp/Tu;
Kd = Kp*Tu/8;

H = pid(Kp, Ki, Kd)
L = H*G;
T = feedback(L, 1);
disp(stepinfo(T))
```

```
Gm =

   12.8000


Pm =

   72.6371


Omegacg =

     4


Omegacp =

    0.6108


Ku =

   12.8000


Tu =

   10.2875


H =

               1
  Kp + Ki * --- + Kd * s
               s

  with Kp = 7.68, Ki = 1.49, Kd = 9.88

Continuous-time PID controller in parallel form.
         RiseTime: 0.1477
    TransientTime: 6.3050
     SettlingTime: 6.3050
      SettlingMin: 0.8536
      SettlingMax: 1.1980
        Overshoot: 19.7969
       Undershoot: 0
             Peak: 1.1980
         PeakTime: 0.3277
```

problem 3

```
s  = tf('s');
G = 10/(s*(s+4)^2);

[H, info] = pidtune(G, 'PID', 4, pidtuneOptions(PhaseMargin = 40, DesignFocus
= "disturbance-rejection"))

L = H*G;
T = feedback(L, 1)
disp(stepinfo(T))
```

```
H =

             1
  Kp + Ki * --- + Kd * s
             s

  with Kp = 9.81, Ki = 9.14, Kd = 2.63

Continuous-time PID controller in parallel form.

info =

  struct with fields:

              Stable: 1
    CrossoverFrequency: 4
          PhaseMargin: 40.0000


T =

         26.28 s^2 + 98.05 s + 91.45
  -----------------------------------------
  s^4 + 8 s^3 + 42.28 s^2 + 98.05 s + 91.45

Continuous-time transfer function.
         RiseTime: 0.2783
    TransientTime: 1.4205
     SettlingTime: 1.4205
      SettlingMin: 0.9421
      SettlingMax: 1.3888
        Overshoot: 38.8802
       Undershoot: 0
             Peak: 1.3888
         PeakTime: 0.7218
```

problem 4

```
Kp = 9.81;
Ki = 9.14;
Kd = 2.63;

s  = tf('s');
G = 10/(s*(s+4)^2);
H = pid(Kp, Ki, Kd)
L = H*G
T = feedback(L, 1);
```

```
H =

              1
  Kp + Ki * --- + Kd * s
              s

  with Kp = 9.81, Ki = 9.14, Kd = 2.63

Continuous-time PID controller in parallel form.

L =

  26.3 s^2 + 98.1 s + 91.4
  ------------------------
    s^4 + 8 s^3 + 16 s^2

Continuous-time transfer function.
```

part a

```
Dm = allmargin(L).DelayMargin
Ur_min = 1/Dm
```

```
Dm =

    0.1745


Ur_min =

    5.7315
```

part b

```
tau = 0.05
Ld = L * exp(-s*tau)
```

```
[Gm, Pm, Omegacg, Omegacp] = margin(Ld)
Gm_mag = 20*log10(Gm)
```

```
tau =

    0.0500


Ld =

                   26.3 s^2 + 98.1 s + 91.4
  exp(-0.05*s) * ------------------------
                     s^4 + 8 s^3 + 16 s^2

Continuous-time transfer function.

Gm =

    3.3669


Pm =

   28.5408


Omegacg =

    8.7507


Omegacp =

    4.0019


Gm_mag =

   10.5446
```

part c

```
Td = G/(1+L);

omega = logspace(-2,3,20000);
mag = abs(freqresp(Td, omega));

omega_err = omega(mag > 0.01);
band = [min(omega_err), max(omega_err)]
```

```
[mag_max, i_max] = max(mag)
omega_peak = omega(i_max)
```

```
band =

    0.0915   10.2837


mag_max =

    0.1391


i_max =

        9498


omega_peak =

    2.3679
```

part d

```
Ljomega = squeeze(freqresp(L, omega));
Ljomegad = squeeze(freqresp(Ld, omega));

dist = abs(Ljomega + 1);
distd = abs(Ljomegad + 1);

[minDist, i] = min(dist)
[minDistd, id] = min(distd)
```

```
minDist =

    0.5959


i =

       10875


minDistd =

    0.4218


id =
```

```
    10736
```

part e

```
a_vals = logspace(-3,2,200);
ok = false(size(a_vals));

for k = 1:numel(a_vals)
  a = a_vals(k);
  Delta = a*s/(a*s+1);
  M = abs(freqresp(Delta*T, omega));
  if max(M) < 1
    ok(k) = true;
  end
end

a_max = max(a_vals(ok))
```

```
a_max =

    0.2300
```

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