EE3004: Control Engineering - Section ESB350 July - Nov 2018

Tutorial & Homework #8 Due: 18 October 2018

1. Consider the control system shown in Figure 1. Determine the gain K and the time constant T of the controller $G_c(s)$ such that the closed loop poles are located at $-2 \pm 2\mathtt{j}$.

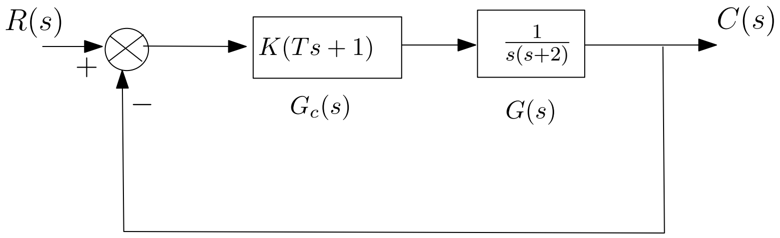

Figure 1

2. Consider the control system shown in Figure 2. Design a compensator such that the dominant closed loop poles are located at $-1 \pm 1\mathtt{j}$. Verify if the dominance conditions have been met or not.

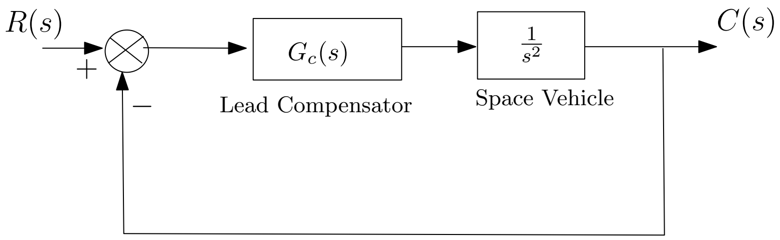

Figure 2

3. Consider the unity feedback system with $G(s) = \frac{1}{(s+4)^3}$.
   (a) Find the location of the dominant poles to yield a 1.6 second settling time and an overshoot of 25%.
   (b) If the compensator with a zero at -1 is used to achieve the conditions of part (a), what must be the angular contribution of the compensator pole be?
   (c) Find the location of the compensator pole.
   (d) Find the gain required to meet the requirements stated in part (a).
   (e) Find the location of the closed loop poles for the compensated system.
   (f) Discuss the validity of your second-order approximation.

4. Consider the unity feedback system with $G(s) = \frac{2s+1}{s(s+1)(s+2)}$. Design a compensator $G_c(s)$ such that the unit-step response curve will exhibit maximum overshoot of 30% or less and settling time of 3 sec or less. Plot the root locus plot of the compensated and uncompensated systems. Plot the compensated and uncompensated output responses for step input. Verify if the dominance conditions has been met or not.

5. Consider the control of a angular-positional system, which is a unity feedback system with $G(s) = \frac{820}{s(s+10)(s+20)}$. The dominant closed-loop poles are located at $s = -3.6 \pm 4.8\mathtt{j}$. The

damping ratio of the dominant closed loop poles is 0.6. The static velocity error constant K_v is 4.1/sec, which means that for a ramp input 360°/sec the steady state error in following the ramp input is

$$e_v = \frac{\theta}{K_v} = \frac{360°}{4.1} = 87.8°.$$

It is desired to decrease e_v to one tenth of the present value, or to increase the value of K_v to 41/sec. It is also desired to keep the damping ratio of the dominant closed-loop poles at 0.6. A small change in the undamped natural frequency ω_n of the dominant closed loop poles is permissible. Design a suitable lag compensator to increase the static velocity constant as desired.

6. Consider the unity feedback system with $G(s) = \frac{16}{s(s+4)}$. Design a compensator $G_c(s)$ such that the static velocity error constant K_v is 20/sec without appreciably changing the original location ($s = -2 \pm 2\sqrt{3}j$) of a pair of the complex-conjugate closed loop poles. Plot the root locus plot of the compensated and uncompensated systems. Plot the compensated and uncompensated output responses for step input. Plot the compensated and uncompensated output responses for a ramp input. Verify if the dominance conditions have been met or not.

7. Consider an unity feedback system with $G(s) = \frac{1}{s(s+2)}$. A controller $G_c(s)$ is placed in cascade with the plant $G(s)$. Sketch the root contour plots for (a) PD controller $G_c(s) = K_P + K_D s$ and (b) PI controller $G_c(s) = K_P + \frac{K_I}{s}$. Here, $K_P > 0$, $K_D > 0$ and $K_I > 0$.

8. Consider the following unity feedback system with disturbance inputs show in Figure 3

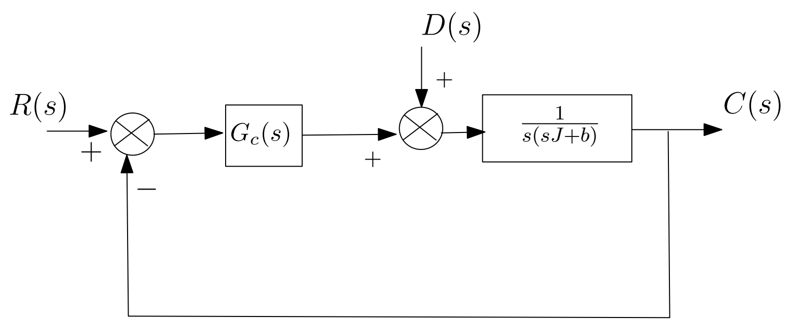

Figure 3

   a) Consider the proportional controller $G_c(s) = K_P$. Assuming $R(s) = 0$ and $D(s) = 1/s$, the unit-step signal, calculate the steady-state error due to disturbance.

   b) Consider the proportional and integral controller $G_c(s) = K_P + \frac{K_I}{s}$. Assuming $R(s) = 0$ and $D(s) = 1/s$, the unit-step signal, calculate the steady-state error due to disturbance. Clearly, mention if any further assumptions are need to be imposed on the parameters of the PI controller.

   c) Discuss the performance of the controllers in (a) and (b) towards disturbance rejection.