Swansea University

College of Engineering

EGLM03 Modern Control Systems

Homework 4: Lag-Lead and PID Compensation

Problems

1. Add a lag compensator to the lead compensator design for Question 3 of the "Dominant Poles and lead Compensation (../lead_compensation/problems)" problem sheet in order to give a position error constant $K_P = 20$.

1. A process control system has open-loop transfer function

$$G_o(s) = \frac{9}{(s+3)^2}.$$

   A PID compensator

$$D(s) = K_p + T_D s + 1/(T_I s)$$

   is placed in cascade with the plant and unity feedback is applied.
   Write down the new closed-loop transfer function and tune the values of proportional gain K_p, differential time T_D and integral rate $1/T_I$ required to give a steady-state open-loop gain of 15, zero step-error, rise-time $t_r \leq 200$ ms and peak overshoot $\%OS \leq 10\%$.

1. Design a PID compensator for the control system with open-loop transfer function

$$\frac{5}{(s+1)(s+5)}$$

   such that the dominant closed-loop poles satisfy $\zeta = 0.5$, $\omega_n = 10$ rad/s and the velocity error constant $K_v = 25$.

1. A cancellation compensator is to be designed to achieve dominant closed-loop poles at $s = -1.5 \pm j2.6$ for the system with open-loop transfer function

$$\frac{K}{s(s+1)}.$$

   Determine the compensation required and the loop gain K of the compensated system. Use the root-locus technique to examine the worst case effect of a 5\% cancellation mismatch due to component tolerances.

1. A control system has open-loop poles at $s = 0$, -1 and -5. Determine the value of the velocity error constant K_v for this system. Use the zero of a lag compensator to cancel the pole at $s = -1$ and position the pole in order to raise the value of K_v by 10. Sketch the root-loci for both the compensated and uncompensated systems and comment on the relative stability of each.

1. Using the plant equation

$$G(s) = \frac{K}{s-1},\ K > 0,$$

and a cancellation compensator $D(s)=\frac{s-1}{s+1} examine the effect on stability of a small error in the compensator zero position.