Swansea University

College of Engineering

EGLM03 Modern Control Systems

Homework 5: Frequency Response Cascade Compensator Design

Problems

1. The uncompensated loop-transfer function of a system is
$$G(s)H(s) = \frac{2}{s(s+2)}.$$
Assuming unity-gain feedback, design a cascade lead compensator to achieve a velocity constant K_v of 20 and a phase margin of 45°.
2. Design a lag compensator for the system of Question 1 to achieve the same design constraints. Compare the relative merits of the two approaches.
3. The open-loop transfer function of a position control system is
$$Go(s) = \frac{25}{s\left(1 + \frac{1}{4}s\right)\left(1 + \frac{1}{16}s\right)}.$$
The system's gain and phase margin are to exceed 1.5 and 15° respectively. Determine whether these specification are satisfied and if not design a lead compensator to meet the specifications and also to maintain the open-loop gain at 25.
4. Using frequency response methods, design a compensator to achieve a step-response with a rise time $t_r \leq 0.4$ s, a peak overshoot $\%OS \leq 20\%$ and a step error constant $K_p = 20$ for the system with plant transfer function
$$\frac{3}{(s+1)(s+3)}.$$
Estimate the closed-loop bandwidth of the compensated system and the resonant peak $M_{\max}$.
5. A type 2 servomechanism has transfer function
$$G(s)H(s) = \frac{0.25}{s^2(1+0.25s)},\ H(s) = 1.$$
Show the effect on stability of adding the cascade lead network:
$$D(s) = \frac{1}{16}\left(\frac{1+4s}{1+0.25s}\right)$$
and a pre-amplifier with gain $K_p = 16.$
6. Repeat the design of Question 4 using the w-transform method to determine the parameters of a suitable digital compensator. Assume that the sampling frequency $\omega_s = 10\omega_{\mathrm{Bw}}$. Write down the difference equation of the resulting digital compensator.