ME 41100 System Dynamics and Control Dr. B. Wang

Spring 2024

Homework 6

Problem 1. Sketch the asymptotes of the Bode plot magnitude and phase for each of the following open-loop transfer functions. After completing the hand sketches, verify your result using Matlab. Turn in your hand sketches and the Matlab results on the same scales.
(Plots should be accompanied by satisfactory explanations, e.g., intermediate steps, as we did in class.)

1) $KG(s) = \dfrac{2000}{s(s+200)}$

2) $KG(s) = \dfrac{(s+5)(s+10)}{s(s+1)(s+100)}$

3) $KG(s) = \dfrac{1}{s^2+3s+10}$

4) $KG(s) = \dfrac{(s^2+1)}{s(s^2+4)}$

5) $KG(s) = \dfrac{(s+1)^2+1}{s^2(s+2)(s+3)}$

Problem 2. Determine the range of K for which the closed-loop systems are stable for each of the cases below by making a Bode plot for $K = 1$ and imagining the magnitude plot sliding up or down until instability results. Verify your answers by using a rough sketch of a root-locus plot.

1) $KG(s) = \dfrac{K}{(s+10)(s+1)^2}$

2) $KG(s) = \dfrac{K(s+1)}{s^2(s+10)}$

3) $KG(s) = \dfrac{K(s+1)^2}{s^3(s+10)}$

Problem 3. Draw the Nyquist plot for the system in Fig. 1. Using the Nyquist stability criterion, determine the range of K for which the system is stable. Consider both positive and negative values of K.

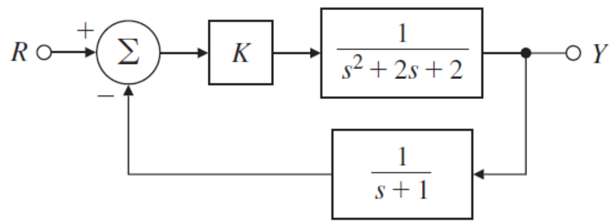

Figure 1: Block diagram of a system.

Problem 4. For the system shown in Fig. 2, determine the Nyquist plot and apply the Nyquist criterion

1. to determine the range of values of K (positive and negative) for which the system will be stable, and
2. to determine the number of roots in the RHP for those values of K for which the system is unstable. Check your answer by using a rough root locus sketch.

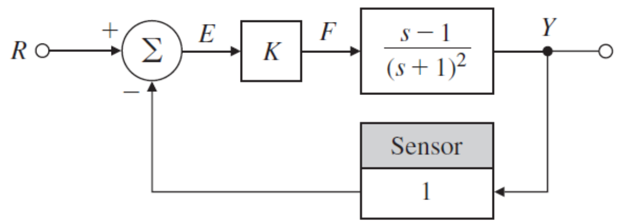

Figure 2: Block diagram of a system.

Problem 5. The open-loop transfer function of a unity-feedback system is

$$G(s) = \frac{K}{s(s/5+1)(s/200+1)}$$

Use Bode plot sketches to design a lead compensator for $G(s)$ so that the closed-loop system satisfies the following specifications:

1. The steady-state error to a unit-ramp reference input is less than 0.01.
2. For the dominant closed-loop poles, the damping ratio $\xi \geq 0.4$.

Problem 6 (Matlab, optional)**.** Consider a Type 1 unity-feedback system with

$$G(s) = \frac{K}{s(s+1)}$$

Use Bode plot sketches to design a lead compensator so that $K_v = 20$ sec^{-1} and $PM > 40°$. Use Matlab to verify and/or refine your design so that it meets the specifications.