Control System: Homework 10 for Units 6I-6K: Bode Plot

Assigned: May 28, 2021

Due: Jun 4, 2021 (11pm)

1. (Lead compensation)

46. For the system shown in Fig. 6.100, suppose that

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

Design a lead compensation $D(s)$ with unity DC gain so that PM $\geq 40°$ using Bode plot sketches. What is the approximate bandwidth of the system?

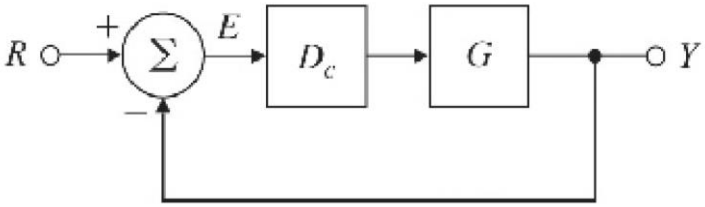

Figure 6.89: Fig. 6.100 Control system for Problem 6.46

2. (Lag compensation)

56. For a system with open-loop transfer function $_c$

$$G(s) = \frac{10}{s[(s/1.4)+1][(s/3)+1]},$$

design a lag compensator with unity DC gain so that PM $\geq 35°$. What is the approximate bandwidth of this system?

3. (Lead-Lag compensation)

62. Consider the system in Fig. 6.100 with the plant transfer function

$$G(s) = \frac{10}{s(s/10+1)}.$$

We wish to design a compensator $D(s)$ that satisfies the following design specifications:

(a) i. $K_v = 100$,
ii. PM $\geq 45°$,
iii. sinusoidal inputs of up to 1 rad/sec to be reproduced with $\leq 2\%$ error,
iv. sinusoidal inputs with a frequency of greater than 100 rad/sec to be attenuated at the output to $\leq 5\%$ of their input value.

(b) Create the Bode plot of $G(s)$, choosing the open-loop gain so that $K_v = 100$.

(c) Show that a *sufficient* condition for meeting the specification on sinusoidal inputs is that the magnitude plot lies outside the shaded regions in Fig. 6.102. Recall that

$$\frac{Y}{R} = \frac{KG}{1+KG} \quad \text{and} \quad \frac{E}{R} = \frac{1}{1+KG}.$$

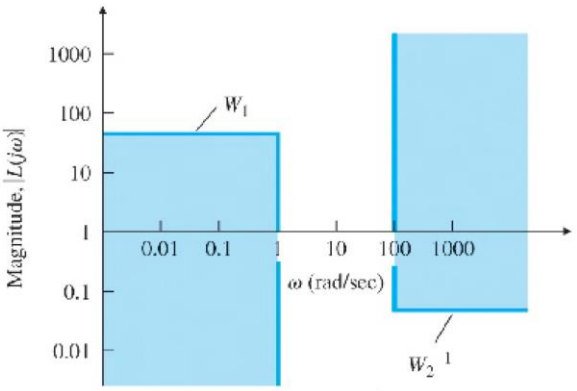

Fig. 6.102 Control system constraints for Problem 62

(d) Explain why introducing a lead network alone cannot meet the design specifications.

(e) Explain why a lag network alone cannot meet the design specifications.

(f) Develop a full design using a lead-lag compensator that meets all the design specifications, without altering the previously chosen low frequency open-loop gain.