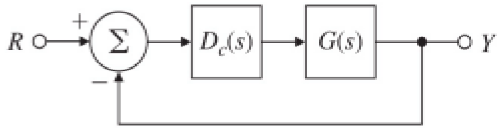
Control System: Homework 07 for Units 5C, 5D, 5E, 5F: Root Locus

Assigned: May 7, 20201

Due: May 14, 2021 (noon)

1. (U5D: Lead-Lag Compensator)

23. Suppose the unity feedback system of Fig. 5.59 has an open-loop plant given by $G(s) = \frac{1}{s(s+1)}$. Design a lead compensation $D_c(s) = K\frac{s+z}{s+p}$ to be added in cascade with the plant so that the dominant poles of the closed-loop system are located at $s = -3.2 \pm 3.2j$.



2. (U5D: Lead-Lag Compensator)

26. A servomechanism position control has the plant transfer function

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

You are to design a series compensation transfer function $D_c(s)$ in the unity feedback configuration to meet the following closed-loop specifications:

- The response to a reference step input is to have no more than 16% overshoot.
- The response to a reference step input is to have a rise time of no more than 0.4 sec.
- The steady-state error to a unit ramp at the reference input must be less than 0.05.

(a) Design a lead compensation that will cause the system to meet the dynamic response specifications, ignoring the error requirement.

(b) What is the velocity constant K_v for your design? Does it meet the error specification?

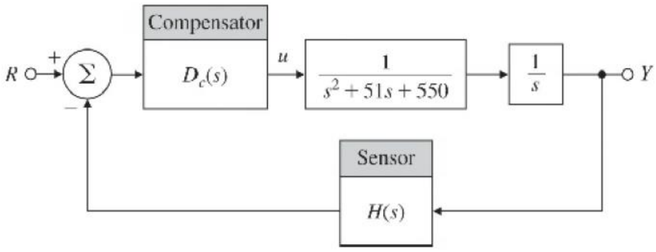
(c) Design a lag compensation to be used in series with the lead you have designed to cause the system to meet the steady-state error specification.

(d) Give the Matlab plot of the root locus of your final design.

(e) Give the Matlab response of your final design to a reference step.

3. (U5E: Design using the Root Locus)

40. Consider the instrument servomechanism with the parameters given in Fig.5.68. For each of the following cases, draw a root locus with respect to the parameter K, and indicate the location of the roots corresponding to your final design.



(a) *Lead network* : Let

$$H(s) = 1, \quad D_c(s) = K\frac{s+z}{s+p}, \quad \frac{p}{z} = 6.$$

Select z and K so that the roots nearest the origin (the dominant roots) yield

$$\zeta \geq 0.4, \quad -\sigma \leq -7, \quad K_v \geq 16\frac{2}{3}\text{sec}^{-1}.$$

(b) *Output-velocity (tachometer) feedback*: Let

$$H(s) = 1 + K_T s \quad \text{and} \quad D_c(s) = K.$$

Select K_T and K so that the dominant roots are in the same location as those of part (a). Compute K_v. If you can, give a physical reason explaining the reduction in K_v when output derivative feedback is used.

(c) *Lag network* : Let

$$H(s) = 1 \quad \text{and} \quad D(s) = K\frac{s+1}{s+p}.$$

Using proportional control, is it possible to obtain a $K_v = 12$ at $\zeta = 0.4$? Select K and p so that the dominant roots correspond to the proportional-control case but with $K_v = 100$ rather than $K_v = 12$.