Student Code Number:_____

Ph.D. Qualifying Exam

Dynamic Systems and Control

Spring 2015

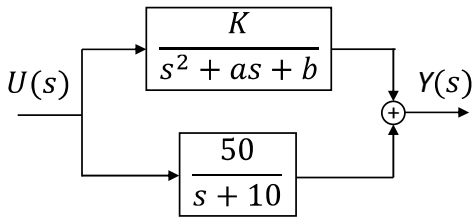
Professor George Zhu
Professor Ranjan Mukherjee

Department of Mechanical Engineering
Michigan State University
(11-24-2014)

Open Book
Answer All Questions
All Questions Weight Equally

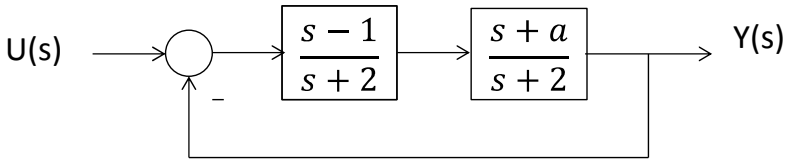
Time: 3.0 hours

1. Consider the following parallel system, where $K > 0$, $a > 0$ and $b > 0$ are three system parameters. Find K, a and b such that the step response of the parallel system has 5% overshoot, 4.0 seconds 2% settling time, and $\lim_{t \to \infty} y(t) = 10$, where $y(t)$ is the unit system step response.



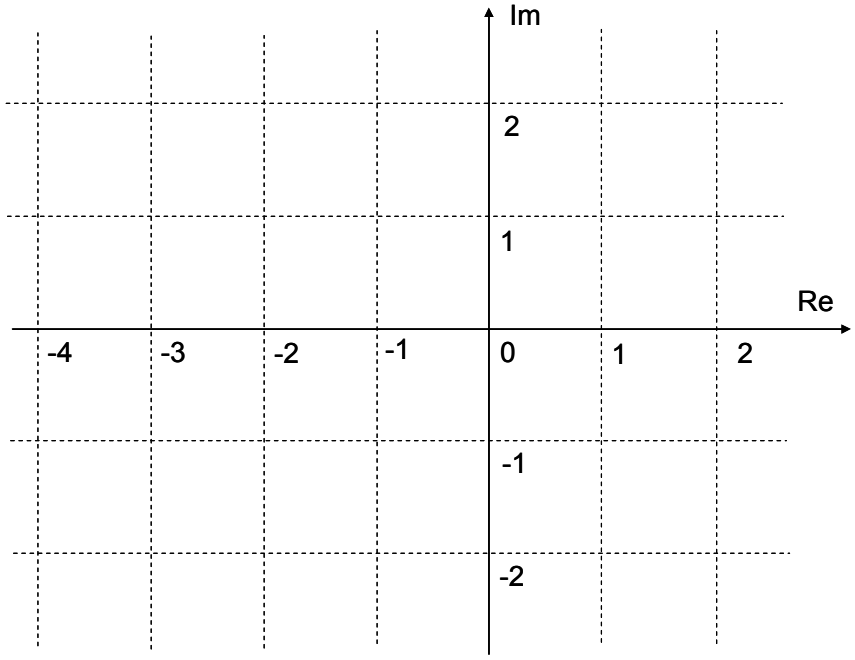
Sol:

2. Consider the following closed loop system

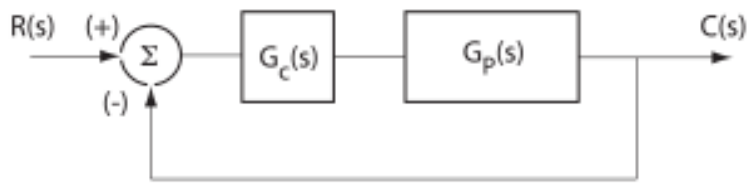


a) Find the closed loop characteristic equation
b) Calculate the breakaway points on the Root Locus
c) Calculate the stabilize range for a when the system is marginally stable.
d) Sketch the Root Locus for $a > 0$ in the next page

Sol:


Im
2
1
Re
-4
-3
-2
-1
0
1
2
-1
-2

3. Consider the closed-loop system shown in the figure below, where $G_p(s) = \frac{1}{s(s+4)}$

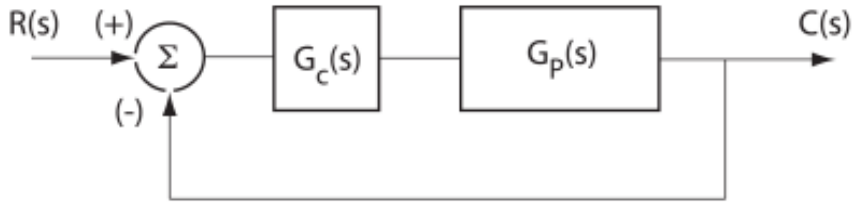


a) Design a phase-lead compensator $G_c(s) = K\frac{s+z}{s+p}$ such that the closed-loop system has poles at $s = -4 \pm 2j$. Use $p = 6$ in your design.
b) Without computing the location of the third pole, comment on the stability of the closed-loop system.

Sol:

4. Consider the closed-loop system shown in the figure below, where

$$G_c(s) = K\frac{s+5}{s+10} \text{ and } G_p(s) = \frac{1}{s(s+1)}$$



a) For $K = 1$, sketch the Bode plots for the open-loop function.
b) From your plots, determine the gain and phase margin of the system.

Sol: