Department of Mechanical Engineering
Cleveland State University

MCE 441: Introduction to Linear Control Systems
MCE 541: Linear Control Systems
Homework 6 - Fall 2009

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1.

The transfer function

$$G(s) = \frac{s-3}{s^3 - s^2 + s + 2}$$

is placed in a unity negative feedback loop under proportional control with gain $k = 1$. Use the Nyquist criterion to predict the number of unstable closed-loop poles. Verify the answer by finding the closed-loop transfer function and its poles.

2.

A controller is sought for the following plant:

$$G(s) = \frac{s+2}{s^3 + 3.2s^2 + 1.6s + 3}$$

Consider the following design specifications relative to a step input command:

- Steady-state error less than 10%
- Settling time less than 8 seconds
- Overshoot less than 30%

1. Translate the design specifications into the frequency domain and represent the constraints in a Bode plot of the target loop.
2. Use SISOtool to find a simple controller (lead-lag suggested) that meets the specifications.
3. Find the closed-loop transfer function using the `feedback` command and display the step response, indicating that the specifications have been met.

3.

Find a state-space representation for the transfer function of Problem 1 by hand. Then obtain one using Matlab. Are they the same? Why? Finally, find the transfer function from the Matlab-generated state-space representation and verify that it is the same as the original.

4.

a. Find all equilibrium points of the following nonlinear system for $u = 1$.

$$\begin{aligned} \dot{x}_1 &= -x_1^2 + x_1 x_2 + u \\ \dot{x}_2 &= x_1 + x_2 u \end{aligned}$$

b. Linearize the system about $u = 1$ and the equilibrium point located in the 4th quadrant of the x_1, x_2 plane. Find the state-space matrices of the linearization.