ME 5200/6200 Classical Controls **Fall 2020**

Homework 08 **Due Thurs, Nov. 17, turn in via CANVAS**

Do the following problems and show all your work for full credit. Note: not all problems will be graded, but you must complete all problems to get full credit.

Problem 1 [65 pts]

Consider a unity feedback control system, where the open-loop plant transfer function be given by

$$G(s) = \frac{a}{(s+b)}$$

with a=0.1 and b=10.

Design a PID controller to yield good step response by using the Ziegler-Nichols tuning method:

(a) [10 pts] Sketch the closed-loop block diagram and label all signals and blocks.
(b) [5 pts] Write the transfer function for the closed-loop system in terms of the controller parameters, Kp, Ki, and Kd and the open-loop system.
(c) [10 pts] Using Matlab, make a plot of the step response (unit step input) for the open-loop system G(s). What is the steady-state value? What is the settling time?
(d) [20 pts] Now design a PID controller and provide the parameters for Kp, Ki, and Kd based on the Ziegler-Nichols tuning method.
(e) [10 pts] Using Matlab, make a plot of the step response (unit step reference) for the closed-loop system using the PID gains you found from Part (d). Determine the percent overshoot, setting time, and steady-state error.
(f) [10 pts] Next, try to tune the PID gains to further improve the transient and steady-state response, for example, try to reduce the settling time by a factor of 10 if possible, minimize overshot, and achieve as close as possible zero steady-state error. Provide the values you found. This process is trial and error, and you use as a starting point the values from Part (d).

Problem 2 [65 pts]

Consider a unity feedback control system, where the open-loop plant transfer function be given by

$$G(s) = \frac{1}{s(s+b)(s\text{^}2 + 2\xi\omega_n s + \omega_n\text{^}2)}$$

with b=10, ξ = 0.707, and ω_n = 4 rad/s.

Design a PID controller to yield good step response by using the Ziegler-Nichols tuning method:

(a) [10 pts] Sketch the closed-loop block diagram and label all signals and blocks.
(b) [5 pts] Write the transfer function for the closed-loop system in terms of the controller parameters, Kp, Ki, and Kd and the open-loop system.
(c) [10 pts] Using Matlab, make a plot of the step response (unit step input) for the open-loop system G(s). What is the steady-state value? What is the settling time?

(d) [20 pts] Now design a PID controller and provide the parameters for Kp, Ki, and Kd based on the Ziegler-Nichols tuning method.

(e) [10 pts] Using Matlab, make a plot of the step response for the closed-loop system using the PID gains you found from Part (d). Determine the percent overshoot, setting time, and steady-state error.

(f) [10 pts] Next, try to tune the PID gains to further improve the transient and steady-state response, for example, try to reduce the settling time by a factor of 10 if possible, minimize overshot, and achieve as close as possible zero steady-state error. Provide the values you found. This process is trial and error, and you use as a starting point the values from Part (d).