EE 4CL4 – Control System Design

Homework Assignment #7

1. Consider a plant with the nominal model:

   $$G_o(s) = \frac{e^{-0.5s}(s+5)}{(s+1)(s+3)}.$$

   Build a Smith predictor such that the dominant closed-loop poles are located at $s = -2 \pm j0.5$ and the controller $C(s)$ has forced integration (i.e., one pole at $s = 0$).

   What is the nominal complementary sensitivity of the closed-loop system? **(25 pts)**

2. The nominal model for a plant is given by:

   $$G_o(s) = \frac{1}{(s+2)(s+1)^2}.$$

   Using the Ziegler-Nichols Oscillation Method to determine the controller parameters, design a PI controller *that prevents wind-up* if the plant actuator is known to have a maximal movement limit for an input $u(t)$ of −3 and +5. **(25 pts)**

3. Determine the steady-state error in response to an "acceleration" reference $r(t) = At^2/2$ for a one-d.o.f. unity-feedback control loop with:

   a. one,

   b. two, and

   c. three

   open-loop integrators (i.e., poles at $s = 0$), assuming that the open-loop controller and plant satisfy Eqs. (8.6.8)–(8.6.10) of Goodwin et al. **(25 pts)**

4. Consider the feedback control of a plant with nominal model:

   $$G_o(s) = \frac{s+1}{s(s+3)}.$$

   a. Use the pole placement method to synthesize a controller such that the closed-loop poles are at (−2; −2; −2).

   b. Prove that a one-d.o.f. unity-feedback control loop consisting of this plant and controller must exhibit overshoot in response to a step reference.

   c. Design a reference prefilter $H(s)$ to create a two-d.o.f. control loop that does not exhibit overshoot. **(25 pts)**