ECE 421, Spring 2005
HW Assignment #13
Due Tuesday, April 26

For each problem, design a compensator $G_c(s)$ such that all of the specifications are satisfied. Use MATLAB to draw the uncompensated and compensated root locus plots and the compensated closed-loop step responses. You may assume that equations for the standard second-order system are valid when designing the compensator. All problems have unity feedback.

1. A certain plant is described by the following transfer function:

$$G_p(s) = \frac{10(s+3)}{s(s+1)(s+5)(s+6)} \tag{1}$$

The following specifications must be satisfied by the closed-loop system:

(a) the steady-state error for a unit ramp input must be ≤ 0.1;

(b) the compensated settling time for a step input must be ≤ 4 seconds;

(c) the damping ratio for the dominant closed-loop poles must be ≥ 0.707.

2. A certain plant is described by the following transfer function:

$$G_p(s) = \frac{8}{s(s+4)} \tag{2}$$

The following specifications must be satisfied by the closed-loop system:

(a) the steady-state error for a unit ramp input must be ≤ 0.05;

(b) the compensated settling time for a step input should be 2 seconds;

(c) the percent overshoot for a step input should be $4\% - 5\%$.

3. A certain plant is described by the following transfer function:

$$G_p(s) = \frac{100}{s(s+5)} \tag{3}$$

The following specifications must be satisfied by the closed-loop system:

(a) the steady-state error for a unit ramp input must $= 0.02$;

(b) the compensated settling time for a step input must be ≤ 1 second;

(c) the percent overshoot for a step input must be approximately 5%.

4. A certain plant is described by the following transfer function:

$$G_p(s) = \frac{5}{(s+4)} \tag{4}$$

The following specifications must be satisfied by the closed-loop system:

(a) the steady-state error for a unit **ramp** input must $= 0.5$;
(b) the compensated settling time for a step input should $= 2$ seconds;
(c) the damping ratio for the dominant closed-loop poles should be 0.707.

5. A certain unstable plant is described by the following transfer function:

$$G_p(s) = \frac{10(s-3)}{s(s-5)} \tag{5}$$

The following specifications must be satisfied by the closed-loop system:

(a) one closed-loop pole must be located at $s = s_1 = -2 + j5$;
(b) the closed-loop system must be stable.

6. A certain plant is described by the following transfer function:

$$G_p(s) = \frac{5}{s^2} \tag{6}$$

The following specifications must be satisfied by the closed-loop system:

(a) the compensated settling time for a step input should be about 4 seconds;
(b) the frequency of oscillation in the step response should be 1 rad/sec;
(c) the steady-state error for a unit parabolic input should be 0.05.

7. A certain plant is described by the following transfer function:

$$G_p(s) = \frac{8}{s(s+4)} \tag{7}$$

(a) the steady-state error for a unit ramp input must be ≤ 0.05;
(b) the compensated settling time for a step input should be 4 seconds;
(c) the percent overshoot for a step input should be $4\% - 5\%$.