

ECE 421, Spring 2005, HW Assignment #14  
Bode Compensator Design Problems  
Due 3:00 p.m., Tuesday, May 10, 2005

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 Bode magnitude and phase plots. All problems have unity feedback.

1. A certain plant is described by  $G_{p1}(s) = \frac{10(0.1s + 1)}{s(s + 1)(0.025s + 1)(0.02s + 1)}$

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

- (a) the steady-state error for a unit ramp input must be 0.01;
- (b) the compensated phase margin must be at least  $60^\circ$ ;
- (c) the settling time for the step response of the compensated system must **not** be less than the settling time for the uncompensated system.

2. A certain plant is described by  $G_{p2}(s) = \frac{1}{s^2(0.5s + 1)}$

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

- (a) the compensated gain crossover frequency  $\omega_{x-compensated}$  must be between 0.1 and 1.0 rad/sec;
- (b) the phase margin must be at least  $30^\circ$ ;
- (c) the steady-state error for a parabolic input must be 1.

3. A certain plant is described by  $G_{p3}(s) = \frac{5}{s(0.5s + 1)(0.1667s + 1)}$

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

- (a) the steady-state error for a unit ramp input must be 0.05;
- (b) the compensated phase margin must be approximately  $45^\circ$ ;
- (c) the compensated gain crossover frequency  $\omega_{x-compensated}$  must be  $> 10$  rad/sec.

4. A certain plant is described by  $G_{p4}(s) = \frac{5}{s(0.5s + 1)(0.1667s + 1)}$

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

- (a) the steady-state error for a unit ramp input must be 0.05;
- (b) the compensated phase margin must be approximately  $45^\circ$ ;
- (c) the compensated gain crossover frequency  $\omega_{x\text{-compensated}}$  must be  $< 10$  rad/sec.

5. A certain plant is described by  $G_{p5}(s) = \frac{20}{s(0.5s + 1)(0.1s + 1)^2}$

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

- (a) the steady-state error for a unit ramp input must be 0.01;
- (b) the compensated phase margin must be at least  $50^\circ$ ;
- (c) the closed-loop bandwidth of the compensated system must be less than the bandwidth for the uncompensated system.

6. A certain plant is described by  $G_{p6}(s) = \frac{100(s + 1)^2}{s(10s + 1)(0.25s + 1)(0.05s + 1)(0.02s + 1)}$

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

- (a) the steady-state error for a unit ramp input must be 0.002;
- (b) the compensated phase margin must be at least  $45^\circ$ ;
- (c) the compensated gain crossover frequency  $\omega_{x\text{-compensated}}$  must be 20 rad/sec.

7. A certain plant is described by  $G_{p7}(s) = \frac{100(s + 1)^2}{s(10s + 1)(0.25s + 1)(0.05s + 1)(0.02s + 1)}$

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

- (a) the steady-state error for a unit ramp input must be 0.002;
- (b) the compensated phase margin must be at least  $50^\circ$ ;
- (c) the compensated gain crossover frequency  $\omega_{x\text{-compensated}}$  must be at least 50 rad/sec.