CONTROL THEORY ASSIGNMENT – DESIGN VIA ROOT LOCUS

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1 Design a PI controller to drive the step response error to zero for the unity feedback system that has an open loop transfer function of:

$$G(s) = \frac{K}{(s+1)(s+3)(s+12)}$$

The system operates with a damping ratio of 0.5. Compare the specifications of the uncompensated system and the compensated system in a table.

2 A unity feedback system that has an open loop transfer function of:

$$G(s) = \frac{K}{(s+2)(s+3)(s+8)}$$

operates with 10% overshoot.

1. What is the value of the appropriate static error constant?
2. Find the transfer function of a lag network so that the appropriate static error constant has a value of 4 without much changing the dominant poles of the uncompensated system.
3. Use Matlab to simulate the system to see the effect of adding the compensator.

3 A unity feedback system that has an open loop transfer function of:

$$G(s) = \frac{K(s+6)}{(s+2)(s+3)(s+5)}$$

is operating with a dominant-pole damping ratio of 0.707. Design a PD controller so that the settling time is reduced by a factor of 2. Compare the transient and steady-state performance of the uncompensated and compensated systems.

4 Consider the unity feedback system that has an open loop transfer function of:

$$G(s) = \frac{K}{(s+4)^3}$$

1. Find the location of the dominant poles to yield a 1.6 s settling time and an overshoot of 25 s
2. If a compensator with a zero at -1 is used to achieve the conditions in Part 1, what must the angular contribution of the compensator pole be?
3. Find the location of the compensator pole.
4. Find the gain required to meet the requirements stated in Part 1.
5. Find the location of the non-dominant closed loop poles for the compensated system.
6. Discuss the validity of the second-order approximation.

5 A unity feedback system that has an open loop transfer function of:

$$G(s) = \frac{K}{(s+15)(s^2+6s+13)}$$

is operating with 30% overshoot.

1. Find the transfer function of a cascade compensator, the system gain, and the dominant pole location that will cut the settling time in half if the compensator zero is at -7.
2. Find other poles and zeros and discuss your second-order approximation.

6 A unity feedback system that has an open loop transfer function of:

$$G(s) = \frac{K}{(s+3)(s+6)}$$

1. Show that the system cannot operate with a settling time of $\frac{2}{3}$ s and a percent overshoot of 1.5% with a simple gain adjustment.
2. Design a lead compensator so that the system meets the transient response characteristics of Part 1. Specify the compensator pole, zero and the required gain.

7 Given the uncompensated unity feedback system that has an open loop transfer function of:

$$G(s) = \frac{K}{s(s+1)(s+3)}$$

do the following:

1. Design a compensator to yield the following specifications: settling time=2.86 s; percent overshoot=4.32%; the steady state error is to be improved by a factor of 2 over the uncompensated system.
2. Compare the transient and steady-state error specifications of the uncompensated and compensated systems.
3. Compare the gains of the uncompensated and compensated systems.
4. Discuss the validity of the second-order approximation.

8 For a unity feedback system that has an open loop transfer function of:

$$G(s) = \frac{K}{s(s+5)(s+12)}$$

do the following:

1. Find the gain K for the uncompensated system to operate with 30% overshoot.
2. Find the peak time and K_v for the uncompensated system.
3. Design a lag-lead compensator to decrease the peak time by a factor of 2, decrease the percent overshoot by a factor of 2, and improve the steady-state error by a factor of 30. Specify all poles, zeros and gains.

9 For a unity feedback system that has an open loop transfer function of:

$$G(s) = \frac{K}{(s+4)(s+6)(s+10)}$$

do the following:

1. Design a controller that will yield no more than 25% overshoot and no more than 2 s settling time for a step input, and zero steady-state error for step and ramp inputs.
2. Use Matlab to verify your design.