Due at 1700, Fri. Oct. 16 in homework box under stairs, first floor Cory .
Note: up to 2 students may turn in a single writeup. Reading Nise 9, 10-10.5.
Midterm: Thurs. Oct. 22. Location: 101 Barker, 330-5pm.

1. (20 pts) Lag Compensation (Nise 9.2)

Consider open loop plant

$$G(s) = \frac{K}{(s+2)(s+3)(s+7)}$$

with unity feedback.
[2pts] a. Find the gain K for the uncompensated system to operate with overshoot of 10% (Matlab ok).
[1pts] b. Find the value of the appropriate static error constant.
[11pts] c. Design a lag compensator such that the appropriate static error constant equals 4 without appreciably changing the dominant pole locations for the uncompensated system. Specify open and closed-loop poles, zeros and gain.
[4pts] d. Hand sketch the root locus of the original and compensated system, and verify with Matlab (rules1-5,9).
[2pts] e. Show before and after compensation step response using Matlab on same plot.

2. (20 pts) PID Compensation (Nise 9.4)

Consider open loop plant

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

with unity feedback.
[2pts] a. Find the gain K for the uncompensated system to operate with overshoot is less than 25% (Matlab ok).
[12pts] b. Design a PID controller such that overshoot is less than 25%, with $T_s < 2$ sec, with zero steady state error for a step. Specify open and closed-loop poles, zeros and gains.
[4pts] c. Hand sketch the root locus of the original and compensated system, and verify with Matlab (rules1-5,9).
[2pts] d. Show before and after compensation step response using Matlab on same plot.

3. (20 pts) Lag-Lead compensation (Nise 9.4)

Consider open loop plant

$$G(s) = \frac{K}{(s+2)(s+4)(s+6)(s+8)}$$

with unity feedback.
[2pts] a. Find the gain K for the uncompensated system to operate with damping ratio =0.5 (Matlab ok).
[2pts] b. Find the settling time and K for the uncompensated system.
[10pts] c. Design a lead-lag compensator to decrease the settling time by 0.5 second, and improve steady state error for a step by factor of 30. (The compensator zero is at $s = -5$.) Specify open and closed-loop poles, zeros and gain.
[4pts] d. Hand sketch the root locus of the original and compensated system, and verify with Matlab (rules1-5,9).
[2pts] e. Show before and after compensation step response using Matlab on same plot.

4. (15 pts) Bode Plot (Nise 10.2)

Sketch (by hand) the asymptotes of the Bode plot magnitude and phase for each of the following open-loop transfer functions. Verify sketch using MATLAB plot with same axes scales, and turn in (log frequency, and magnitude in dB).

a) $\frac{1000(s+10)}{(s+1)(s+100)}$ b) $\frac{1}{s(s^2+2s+101)}$ c) $\frac{100s}{(s+1)(s+100)}$

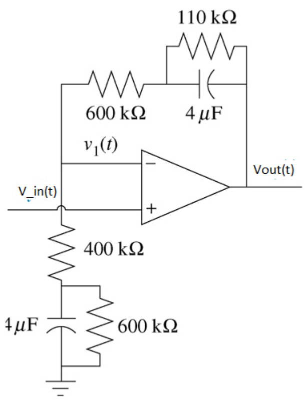
5. (15 pts) Compensation Network (Nise 9.6, 10.2)

For the ideal op amp circuit below:

[4pts] a) Determine the transfer function $T(s) = \frac{V_{out}(s)}{V_{in}(s)}$. Express the transfer function as a standard rational function (polynomial numerator, polynomial denominator).

[8pts] b) Hand sketch the Bode plot for magnitude and phase.

[3pts] c) Verify sketch using MATLAB plot and turn in plot.



6. (25 pts) Nyquist Plot (Nise 10.5)

Consider a closed loop system with unity feedback. The open loop transfer function is:

$$G(s) = \frac{k(s^2 + 2s + 64)}{(s+3)^2(s+6)^2}$$

[6pts] a) Hand sketch the asymptotes of the Bode plot magnitude and phase for the open-loop transfer functions.

[10pts] b) Hand sketch Nyquist diagram.

[4pts] c) From Nyquist diagram, determine range of k for stability.

[5pts] d) Verify sketches with MATLAB (`bode()` and `nyquist()`) and hand in.