Due at 1800, Fri.Oct. 30 in gradescope. .

Note: up to 2 students may turn in a single writeup. Reading Nise 10, 11

1. 1. (24 pts) Time Delay (Nise 10.12. 10.10)

Given a unity feedback system with forward path O.L. transfer function

$$G(s) = \frac{100}{s(s+10)} \ .$$

Assume an added delay in the feedforward path, for example from WiFi state update rate from Tello, of ΔT.

[2pts] a) Draw a block diagram for the system, including ΔT propagation delay for error $e(t)$ to reach the controller/plant $G(s)$.

[2pts] b) Draw Bode diagrams for the system without delay, and estimate gain and phase margin. (Matlab ok)

[8pts] c) Determine ΔT for a 30° reduction in phase margin for the system with delay, and draw Bode phase diagram w/delay (Matlab ok for these Bode diagrams.)

[8pts] d) Estimate overshoot and settling time from second order approximation for both cases.

[4pts] e) Use Matlab to plot the step response for the closed loop system with and without delay and compare to the estimate from part d). (Use `Gdelay=tf(num,den,'InputDelay',deltaT)` to include time delay in the system.)

2. (10 pts) Lag network design (Nise 11.3, Fig. 11.5)

[8pts] a) Design a lag network $G_c(s) = k\frac{s+z_c}{s+p_c}$ such that DC gain is +15 dB, and ~~peak~~ phase contribution at desired phase margin frequency $\omega_{pm} = 30$ rad/sec is ~~greater~~ no worse than $-10°$.

[2pts] b) verify lag network design with Matlab.

3. (28 pts) Lag Compensation (Nise 11.3)

Given unity feedback system with OLTF:

$$G(s) = \frac{150(s+3)}{(s+5)(s+1)^2(s+10)}$$

[8pts] a) Sketch by hand the Bode plot for $G(j\omega)$.

[16pts] b) Design a lag compensator $G_c(s)$ (using methods of Ch 11) such that the phase margin is at least 65°, and the static error constant = 100 and plot the Bode plot for the compensated OLTF (Matlab ok).

[4pts] c) Use Matlab to plot the closed-loop step response for the compensated and uncompensated system, and compare steady state error. Also use `margin` to check design spec is met.

4. (10 pts) Lead network design (Nise 11.4, Fig. 11.8)

[8pts] a) Design a lead network $G_c(s) = k\frac{s+z_c}{s+p_c}$ such that high frequency gain is +10 dB, and peak phase contribution is +30° at $\omega = 100$ rad/sec.

[2pts] b) verify lead network design with Matlab.

5. (28 pts) Lead Compensation (Nise 11.4)

Given unity feedback system with OLTF:

$$G(s) = \frac{20(s+10)}{(s+1)^2(s+6)^2}$$

[8pts] a) Sketch by hand the Bode plot for $G(j\omega)$.

[16pts] b) Design a lead compensator using frequency domain techniques (of Ch 11) , such that DC gain of the system is unchanged, and phase margin is 40°, and plot the Bode plot for the compensated OLTF (Matlab ok).

[4pts] c) Use Matlab to plot the closed-loop step response for the compensated and uncompensated system, and compare steady state error and settling time. Also use `margin` to check design spec is met.