Due Monday, November 9 EE571 HW#21

Note: HW21 is also due on November 9th, as well.

1\. a) Find regions in the complex S-plane where dominant 2nd order poles can be placed to satisfy the following transient response specifications:

i) $\zeta \geq 0.2$ ii) $M_p < 50\%$ iii) $t_s < 0.1s$ iv) $\zeta \geq 0.2$ and $t_p < 0.1s$

b) Which pole is dominant for the closed-loop transfer function, $\frac{Y(s)}{W(s)} = \frac{20}{(s+1)(s+20)}$. To verify your answer, plot the impulse of the transfer function and the function $x(t)=(20/19)e^{-t}$ on the same graph.

c) Repeat part b) but use the transfer function, $\frac{Y(s)}{W(s)} = \frac{20(s+1.05)}{(s+1)(s+20)}$. This time, plot the function $x(t) = 20e^{-20t}$ along with the impulse response. Why isn't the pole at s=-1 dominant?

Josh and Tyler compensating an old A-6 Intruder Jet

Given the recent $25,000,000,000 contract to build the new Joint Strike Fighters, Josh and Tyler decide to form their own company, JoshandTyler, LLC, to compete with Lockheed-Martin and Northrup Grumman. Rather than designing a new fighter plane from scratch, Josh and Tyler decide to buy a whole bunch of old surplused A-6 intruder jets with the intention of making them faster and stealthy. Since they haven't taken our EMC course, EE527, they decide to wait on the stealthy part and focus on improving the performance of the old A-6s. Using techniques similar to the ones they learned in Labs 1 and 2, Josh and Tyler have found the following open-loop transfer function for the A-6's YAW dynamics:

$$G(s) = \frac{20}{s(s+4)(s+40)}, \quad H(s) = 1$$

d) What is the type number of the system? What is $ess|_{unit\ step}$ and $ess|_{unit\ ramp}$?

e) Sketch the uncompensated root locus of the A-6. How much gain can we put into the forward loop before the A-6 becomes unstable in its YAW motion?

2.a) Design a lead compensator for the US Navy's A-6 to improve its YAW response so that the JoshandTyler, LLC can tell the Pentagon that their plane meets the following specifications:

1. t_s = 1 second
2. Damping coefficient of ζ = 0.707
3. $ess|_{step} = 0$

b) Now design a lag compensator to put in series with the lead compensator in 2a) so that the A-6 meets the following additional steady-state error requirement:

$ess|_{ramp} = 1/20$

c) Sketch both the lead compensated and the lead-lag compensated root loci (you can use Matlab's rlocus() to help you).

d) Use MATLAB's roots() function to find the closed-loop poles of your lead compensated and your lead/lag compensated design (i.e., find the roots of $1+G_cG = 0$ and the roots of$1+G_cG_{LAG}G = 0$). For the closed-loop Lead/Lag system, the closed-loop pole near the origin is NOT the dominant pole. Why not?