EE363 Automatic Control: Homework #7

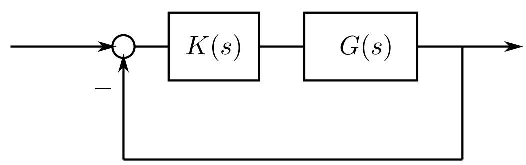
1) *Bode plots.* Sketch the Bode magnitude and phase plots, not by using computers, to the accuracy of the asymptotes.

a) $$G(s) = \frac{2000(s+0.5)}{s(s+10)(s+50)}$$

b) $$G(s) = \frac{1000(s+1)}{s(s+2)(s^2+8s+64)}$$

c) $$G(s) = \frac{4s(s+10)}{(s+50)(4s^2+5s+4)}$$

2) *Lead/lag compensation.* Consider the following system in the unity feedback configuration.



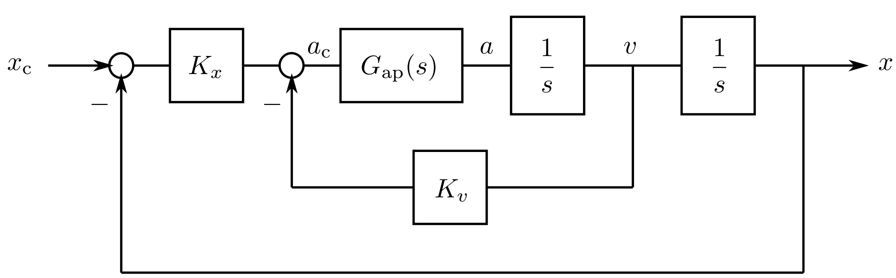
$$G(s) = \frac{s+4}{s^2}$$

a) Design a simple lead or lag compensator, $K(s)$, that will place the dominant poles of the closed-loop system at $s = -2 \pm 2j$. What is your $K(s)$? Hint. your compensator may cancel the plant zero.

b) Draw the Bode diagrams of $K(s)G(s)$. You may use MATLAB.

c) What is the gain margin and the phase margin of your design?

3) *Runway approach problem.* Recall the runway approach problem for an aircraft, which we discussed several times in class. Your job is to design a controller that computes the acceleration command, a_c, from the lateral deviation, x, and the lateral velocity, v, that is, to choose K_v and K_x, and to check the robustness of your design. The block diagram describing the dynamics of the considered system is shown below.



Your controller computes the acceleration command, a_c, which is sent to the autopilot that somehow generates the actual acceleration response, a, through $G_{ap}(s) = a(s)/a_c(s)$. For now, assume that the autopilot is ideal, $G_{ap}(s) = 1$.

a) Find K_v and K_x that place the closed loop pole at $s = -1 \pm j$, so that the closed loop bandwidth is 2 and the closed loop damping is $1/\sqrt{2}$.

Now fix K_v and K_x by the ones you found in a), and we assume that K_x is disturbed by a scale factor $\xi > 0$, so the new position gain can be ξK_x while the velocity gain stays the same as K_v.

b) For what range of ξ, is the closed loop system stable? You may use MATLAB to check the stability margin of your design.

A more realistic autopilot can be modelled by a third order system as

$$G_{\mathrm{ap}}(s) = \frac{a(s)}{a_{\mathrm{c}}(s)} = \frac{p\omega^2}{(s+p)(s^2 + 2\zeta\omega s + \omega^2)}$$

where we let $\omega = 4$, $\zeta = 0.7$, and $p = 6$.

c) Under presence of this autopilot model, for what range of ξ, is the closed loop system stable? You will need to use MATLAB to check the stability margin of your design.