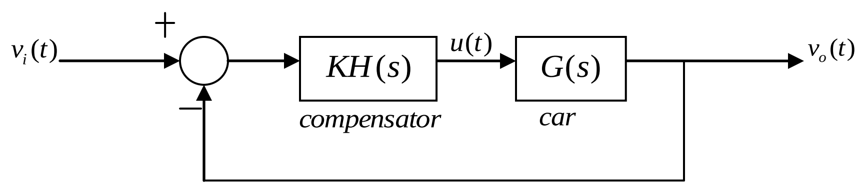
The University of Connecticut **Fall 2012**
Dept. of ECE **KRP**

ECE 6095
Problem Set # 5
(Due November 6, 2012)

1. Design the PI controller for the cruise control problem of HW set #1.
2. Design the lead network for the armature-controlled DC motor of HW set #1.
3. Shown is a proposed speed control system for an automobile, where $v_o(t)=$ output velocity, $v_i(t)=$ input(command, refrence)velocity, and $u(t)$ is the fuel flow.



The transfer function between fuel flow and speed is assumed to be:

$$G(s)=\frac{1}{(1+0.08s)^2}$$

We require the car to follow an input speed profile that goes linearly from 0 to 60 mph in 10 seconds, with a steady state error of no more than 0.3 mph. Also, we would like the system to not be sluggish, so a phase margin of $\geq 30^\circ$ is suggested.

a. Design a lag compensator (plus whatever you think is appropriate…. Note G(s) is Type 0 system!) with
$\omega_g / \alpha\omega_1 = 10$.
b. Using MATLAB, evaluate the closed loop poles and the response $v_o(t)$ to a unit step input for the design in (a)
c. Design an IMC controller for the closed-loop transfer function corresponding to the above design.

4. Design a lead network with $\beta \leq 20$ for a system with $G(s)=\dfrac{5}{s(0.05s+1)}$ such that:

(a) $K_v = 50$
(b) errors in following sinusoidal inputs for $\omega \leq 2$ should be < 10%
(c) phase margin $\phi_m \approx 45^\circ$, with crossover frequency as large as possible.
Evaluate your design, especially its sensitivity with respect to variations in the nominal system time constant of 0.05 sec. Are you satisfied with the system's performance if the time constant drops to 0.04 sec? increase to 0.06 sec?
(d) What is the maximum time-delay that could be tolerated in G(s) before the closed-

loop system as designed becomes unstable?

5. Design an IMC controller for the non-minimum phase system (a model of a chemical reactor)

$$G(s) = \frac{-1.117s + 3.1472}{s^2 + 4.6429s + 5.3821}$$

where time unit is in minutes. The settling time should be less than 3 minutes. It must track step inputs with zero error.

6. (This will require a higher order compensator) The plant is a single integrator 1/s. The loop transfer function must behave as a single integrator at zero frequency. The gain and phase margins must be not less than 10dB and 30^0, respectively. The cross over frequency must be not less than 0.9 rad/sec, but the loop gain at frequency 10 rad/sec and higher must not exceed -35dB.