6.302 Feedback Systems

Introduction

The purpose of this lab is to utilize the mathematical model obtained for the servo-mechanism to design a position control loop. You will need a copy of all the motor parameters determined in Lab 1A. Be sure to include the inertia of the flywheel in all of your calculations. Measurements will be made next week to verify calculated results. This prelab **must** be done before you go into lab.

Pre-Lab Calculations

Consider the following tachometric feedback position control loop:
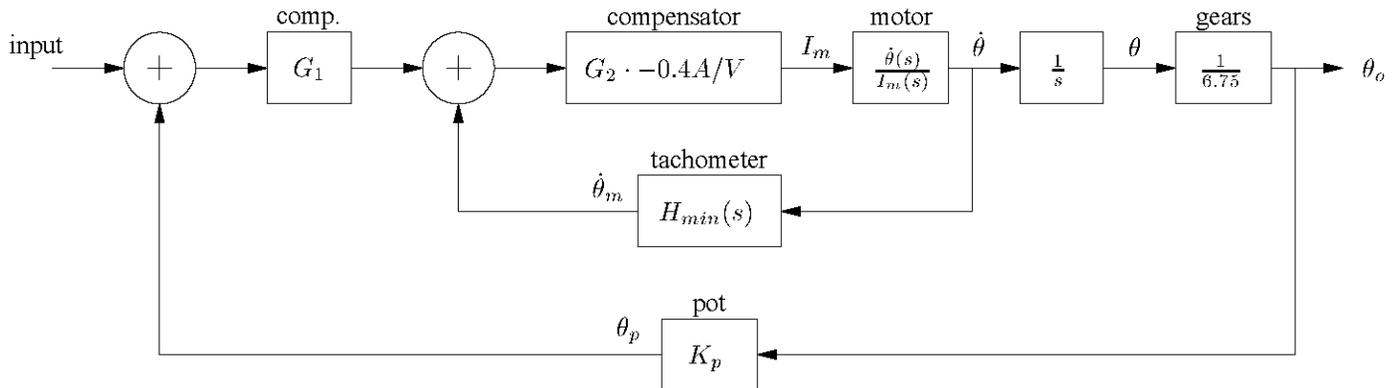
First consider the scenario in which $H_{min}(s)$ is just a constant, K_{tach}.

1. Let G_1 and G_2 be constant gains. Draw root locus plots and explain how this feedback scheme lets you independently set the natural frequency and damping ratio. (Hint: consider closing the minor (inner) loop and setting its gain first, and then closing the major (outer) loop and varying its gain. Draw a couple of root locus plots that show how varying G_2 affects the root locus plots for G_1.

2. Calculate the values of G_1 and G_2 such that $\omega_n = 28$ and $\zeta = 0.5$ rad/sec for the closed loop system. Note that these values are similar to the performance obtained in last week's lab.

3. Calculate the steady state error of this system to a unit ramp input.

Now consider using a frequency dependent network in the minor loop feedback path (H_{min}). Such a network is called " acceleration feedback" if its transfer function is of the following form:

$$H_{min}(s) = K_{tach}\frac{\tau s}{\tau s + 1}$$

For this laboratory, choose $\tau = 0.2$ sec.

4. Draw root locus plots and explain how this system lets you independently set ζ and ω_n. (Hint: you may want to use block diagram manipulations to simplify the minor loop to unity feedback.)

5. Using the values for G_1 and G_2 that you calculated in part 2, calculate ζ and ω_n for this system. Simplify the problem based upon the root locus diagrams.

6. Calculate the steady state error of this system to a unit ramp.

7. Use a Nichols Chart in MATLAB to find M_p and ζ for this system.

Useful Formulae

$$
\begin{aligned}
\omega_d &= \omega_n \sqrt{1 - \zeta^2} \\
P_o &= 1 + \exp\left(\frac{-\pi\zeta}{\sqrt{1 - \zeta^2}} \right) \\
t_p &= \frac{\pi}{\omega_d} = \frac{\pi}{\omega_n \sqrt{1 - \zeta^2}} \\
M_p &= \frac{1}{2\zeta\sqrt{1 - \zeta^2}} \\
\omega_p &= \omega_n \sqrt{1 - 2\zeta^2}
\end{aligned}
$$