

6.302 Feedback Systems

Spring Term 2008
Prelab 1C

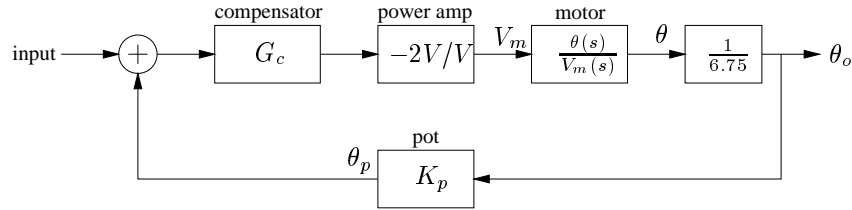
Issued : March 7, 2008
Due : Thursday, March 13, 2008

Introduction

The purpose of this lab is to use the mathematical model obtained for the servomechanism to design a position control loop. You will need a copy of 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

1. Consider the following position control loop:



For a proportional control compensator (i.e. G_c is a constant gain) with a gain of 8.0, calculate the values of ζ and ω_n for the closed loop system.

2. Now consider using a “proportional plus derivative,” or “P+D,” controller. Using the “lead” setting on the control box gives a compensator of the following form:

$$G_c(s) = G \frac{\tau s + 1}{0.1\tau s + 1} \approx G(\tau s + 1)$$

Note that the compensator pole is ignored since it is ten times faster than the frequencies that we consider interesting.

Find the capacitor value required to place the compensator zero at a frequency of ω_n ($\tau = C \cdot 90.9k\Omega$) Use the closest standard capacitor value (i.e. $0.1\mu F$, $0.22\mu F$, $0.33\mu F$, $0.47\mu F$, $1\mu F$, ...).

Calculate the values of ζ and ω_n for the above compensated loop.

Calculate the steady state error of the above system when driven with a unit ramp input.

3. Draw root-locus diagrams for parts 1 & 2.

Useful Formulae

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