

## 6.302 Feedback Systems

Spring Term 2007  
 Lab 1C

Issued : March 6, 2007  
 Due : Friday, March 23, 2007

### Introduction

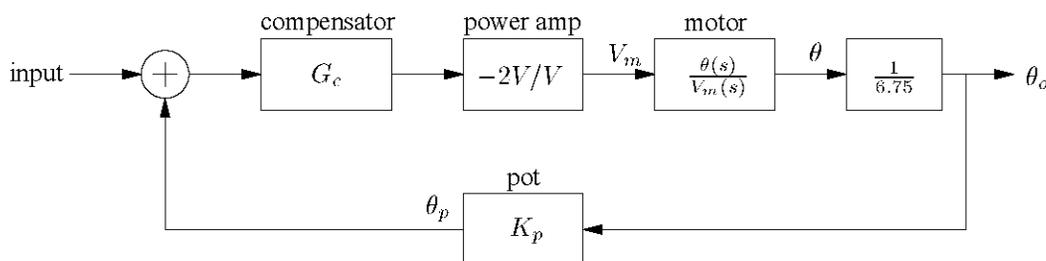
The goal of this laboratory is the design of a position control loop through the use of the mathematical model obtained for the servomechanism in lab 1A. Measurements are made in the laboratory to verify results calculated in the prelab.

### Equipment

For this lab, you will need to pick up the following items from the equipment desk: five BNC cables, 3 BNC T-connectors, and the capacitor that you calculated in the prelab.

### Measurements

Configure the servo-mechanism as shown below (remember the flywheel.) Use the “Summing Amp / Compensator” section on the left side of the control box. Set its switches to the “flat” settings and dial in a compensator gain value of 8.0.



1. Drive the system input with a *square wave* of voltage and measure the percent overshoot and ringing frequency (damped natural frequency) of the output shaft position. Find the values of  $\zeta$  and  $\omega_n$  that correspond to your measurements. Compare your experimental and calculated values. Be sure that you don't over-drive and saturate the system while taking your measurements.
2. Drive the system with a *sine wave* of voltage and find the peak magnitude (gain) of the closed loop response and the frequency at which this peak occurs. Be very careful not to over-drive the system, as a small input magnitude is required for this measurement. Find the values of  $\zeta$  and  $\omega_n$  that correspond to your measurements. Compare your experimental and calculated values.

Place a capacitor of the value which you calculated across the “ $C_{lead}$ ” terminals of the compensator and move its switch to the “lead” setting. The system is now configured with a proportional plus derivative controller. (Plus an additional pole which is fast enough to ignore.)

1. Repeat the above measurements (time domain and frequency domain) on the P+D compensated system. Note that it is quite difficult to accurately measure the ring frequency of the step response. Why is this so? Measure the percent overshoot and the time to peak. You will notice that the measured values of  $P_o$  and  $M_p$  do not match the expected values based on the  $\zeta$  and  $\omega_n$  of a pole pair. Why? Use MATLAB to plot the step and frequency responses of the modeled system with the P+D controller. How do these responses compare to your measured results?

2. Drive the system with a triangle wave of voltage and measure the steady state error to a ramp input. By using the slope of the input ramp, normalize your error measurement to that which would be obtained from a unit size ramp. Note that the error is the sum of the input and  $\theta_p$ . Use the “Channel Math” function on the oscilloscope to facilitate this measurement.

## Write Up

The write up for this lab should be prepared in the same spirit as last week's: short, simple, and informal.

## Useful Formulae

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