Department of Mechanical and Aerospace Engineering
University of Texas at Arlington
Classical Methods of Control Systems Analysis and Synthesis
ME 5303 – SPRING 2001
PROJECT 2: Preliminary Statement

The second project builds on the analysis performed in the first project. In this project, you will design a compensator for the magnetic levitation testbed available in the MARS lab.

Part I

Develop two Simulink block diagrams, one each for each model of the electromagnet. Simulate and observe the response for three inputs, a step, sinusoidal and square wave. Using the developed block diagrams, identify the stability limits using Ruth-Hurwitz, root locus, and Bode plots. You could use computer tools for part of this analysis. You will use this block diagrams later in implementing and evaluating the performance of your lead compensator.

Part II

Design a compensator for each of model of the electromagnet. **The performance specifications must be defined by you and approved by the instructor based on the physical system.** Verify the performance of your compensator in the Simulink block diagrams developed in Part I for the various reference inputs. Experiment by changing the magnitude of the step input, and magnitude and frequency of sin and square waves.

After you design your compensator in the continuous time domain (s-operator), you will implement it in the discrete time domain (z-operator) using the Tutsin or bilinear transformation or use MATLAB (c2d: continuous to discrete). This transformation is required since the digital environment samples data at discrete time intervals. The sampling period to be used in your transformation is Ts = 0.001 sec. Note that this sampling period is the one currently defined in all the blocks in the experimental testbed. You could change this and experiment with the effect of the sampling period if desired, but you must change all the references in the Simulink block diagram.

NOTE: If you DO change the sampling period
SAVE the Simulink model under a different name say LASTNAME
using SAVE AS command
DO NOT SAVE IT UNDER THE SAME NAME.

Tutsin or Bilinear Transformation: $s = \frac{2}{Ts} * \left(\frac{z-1}{z+1}\right)$

This transformation will yield transform the continuous time compensator transfer function to the discrete domain, say $Gcomp(s) = K * \frac{s+a1}{a+a2} \Rightarrow \left[s = \frac{2}{Ts} * \left(\frac{z-1}{z+1}\right)\right] \quad Gcomp(z) = Kc * \frac{z-a}{z-b}$. It will be advantageous to find the expressions for the discrete compensator variables as functions of the continuous controller parameters. The final discrete compensator is the one to be implemented in MATLAB and then evaluated on the hardware.

Electromagnet Models

- Model 1:

Resistor (R) and Inductor (L) in Series

- Model 2:

System 1: Inductor (L) and Capacitor (C) in parallel
System 1 and Resistor (R) in series

(R=25 Ohm, L = 0.57 Henry, C = 250E-6 F)

Note on Electromagnetic Models:
There have been some questions about the analysis for the second model of the electromagnet. The questions focused on the finding the current through the inductive part of the circuit and then use this current as a state variable or use it in finding the transfer function of the plant (distance of ball / applied voltage to electromagnet) about the linearization point.

Please note that you should not try to identify the inductive or capacitive current. This is a lump parameter representation and the current to be used in the analysis is the total current to this model. It is very important to understand that we cannot use the inductive current since the total system represents the electromagnet.

Apply the following:
V across electromagnet = Total Current * Total Impedance
Total Impedance = Impedance of Resistor + (Impedance of Ind. & Cap. in Parallel)
Impedance of Ind. & Cap. in Parallel = (Imp of Ind. * Imp. of Cap.) / (imp. Ind. + Imp. of Cap.)

You can evaluate the relationship between V across and Current as function of R, L, and C. Then, proceed as usual.