Grading sheet companion
The cart on a track

AAE 364L

Objectives/Goals/Purposes

This experiment consists of five parts. What are the objectives of each part? Becoming familiar with equipments and Simulink is not an objective of the experiment. Also, since a controller is already designed in pre-lab, designing a controller is not an objective here either. *Variables cannot be used here since you have yet to define them.*

Intended Methods

How would you achieve your objectives? What kind of inputs do you feed into the system and what kind of outputs do you measure? Do not go into specific details. That is what the procedure section is for.

Definition of Variables

What are the variables you use in your report? Include only those variables that you use and mention. Extra variables that are not mentioned in your report are of no interest to the reader.

Schematic and Description of Apparatus

Include picture(s) of the apparatus and schematic(s) describing how your variables are defined. Describe how the apparatus is connected, how you feed the inputs and how the outputs are measured. What can be fed in and what can be measured? What are the restrictions or limitations of the apparatus?

Procedure of Experiments

Any scientific experiment must be repeatable. Describe in detail the important steps and the size of the inputs you feed into the apparatus. What do you measure? How long do you measure data? Buffer size, specific name of variables you use in MATLAB, name of your Simulink scopes, logging in and out of computer, starting program, opening file are of no interest to the reader.

Results

All numbers must be accompanied by proper units. Writing a number without unit is meaningless and NO CREDIT will be given. All numbers must have only reasonable significant digits. For example, $m = 1.23456789$ *kg is not reasonable since we have no instrument that can measure mass*

accurate to 10^{-8} *kg. All parameters must be either in tables or equations. Plots of data are not results. Describe what kind of data each table contains. Data that are not related must not be in the same table.*

Analysis and Discussion

Regarding the plot, the time simulation and experiment start must coincide. It is standard to have system response start at time zero. Data must be valid for all the time shown. Only meaningful data can be included. All plots must have proper labels with units and legends. Legends must not lie over the data. Lines must be distinguishable. Data shown in the same figure must be of the same type. For example, position and angle cannot be plotted on the same graph.

Regarding analysis, include only equations that you use and refer to. Mention only equations that explain what you are doing to the reader. You are not writing a text book, so be brief and get right to the point. Quality of writing is not proportional to the number of equations used. Clearly separate the facts (shown in data) and your opinions (what can be concluded and supported by data).

Part (i): What is(are) the equation(s) of motion? What assumptions are made? How do you compute m, γ, B_{emf}? How do you compute B_{eq}, c? Give the plot and compare the theoretical and experimental values of y. Why do the plots not coincide initially?

Part (ii): Discuss what saturation is? What is its purpose? What is its size in this case? Give the plots of input voltages from the simulation without saturation, the simulation with saturation, and the actual voltage from the experiment. Show the plot of positions from the simulation without saturation, simulation with saturation, and the experiment. How are these plots generated? Discuss effect of saturation on y. Why does y from the simulation using no saturation reach final value faster? How do you compute the new estimate of B_{eq}?

Part (iii): What is Coulomb friction? How does it affect the dynamics? How do you determine its size here? Show the plot of y when the input voltage is a ramp. What time does the cart start moving? How is this plot generated? What is the size of f_c? What is the upper bound of $|e(\infty)|$? Show the plots of simulation and experimental error. How are these plot generated? What is the actual $e(\infty)$? Is it within bounds?

Part (iv): What is an integral controller? What is its purpose? Why does large k_i cause instability? Give the root locus of k_i. How large can k_i be in this case? Compare the simulation and experimental plots of error. How are these plot generated? Does $e(\infty)$ actually go to zero?

Part (v): What are the specifications of the controller you already designed? What performance do you expect from it according to your simulation? What final values did you choose for your controller? What kind of performance is it capable of? Does it achieve your design objectives? Give the plots of y from the simulation using these final values and the actual y you obtained from the experiment? How are these plots generated? How accurate is your simulation? Say only things that are quantifiable. The words such as "good", "very good", "bad" are not quantifiable. Does your model need adjustment so that in the future you can design a better controller?

Discuss the general effects of k_p, k_i, and k_d on the closed loop system response. What do k_p, k_i, and k_d act like dynamically?

All Simulink models you use must be included in the Appendix. They are not part of your analysis, but you must mention them in your analysis.

Main Points

What did you do in this experiment? What can be concluded from data obtained? Be brief, this is not the place to put in details.

Theoretical/Experimental Limitations

What assumptions have you made in order to analyze your system? What kinds of responses or system properties can be analyzed theoretically but cannot be generated in the real experiment? What can you do and cannot do experimentally, and why? In any scientific experiment, it is always assumed that human error factor is minimal. Thus human error is not a limitation of your experiment.

Personal Lessons Learned and Suggestions for Improvement

If you have nothing to say here, you must state that you have no suggestion at this point. Leaving this part unanswered is equivalent to submitting an incomplete report. Say something constructive, something that will help improve learning experience of students who will take this course next semester.

We have already spent about $60,000 on these equipments, so please do not suggest buying more expensive equipments. If you know of other companies that produce superior equipments with lower or competitive price, please let us know. Please do not suggest something that cannot be done, such as having the entire apparatus in vacuum to eliminate the disturbance from the air.

In this particular experiment, we already know that the gears are made of plastic and are easily broken. So please do not suggest buying new gears.