Grading sheet companion
The control of a gantry

AAE 364L

Objectives/Goals/Purposes

This experiment consists of four 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).

What are the equations of motion? What are the linearized equations of motion? What are the equilibrium points? Which equilibrium point is of interest here? Describe state variables. Define the state vector. What is the input and what are the outputs? Specify system matrices A, B, C, D corresponding to your input and output.

Part (i): What is(are) the assumption(s) made? How do you compute ω_p from the linear approximation, and from the experimental data? Give the plot the experimental values of α.

Part (ii): What is the characteristic polynomial of A? What are the eigenvalues of A? How are the eigenvalues of A related to the characteristic polynomial of A? How do you compute ζ and ω_n from the eigenvalues or the characteristic polynomial of A? What is the transfer function G_α from voltage input to angle output? How do you compute the transfer function? Give the Bode plot of G_α. How do you determine ω_n from the Bode plot? Give the plots of angle when $\omega = 3$ rad/s, ω_n, 7 rad/s. Discuss what happened during transient and steady state period, especially when $\omega = \omega_n$. How do you compute $|G(\imath\omega)|$ from the Bode plot? How do you calculate $|G(\imath\omega)|$ from the experimental data? Are they reasonably close to the values you obtained from the Bode plot?

Part (iii): What is(are) the objective(s) of your controller? What is(are) the specification of your design? How did you design your controller? What assumption(s) is(are) made when you use a linear controller to control a nonlinear system? What is the motivation behind the poles location that you chose? Give the plots of angle when cart is tapped, both from experiment and simulation using the best gain K. How are these plots generated? Is your simulation accurate enough? If so, what is the estimated settling time when the pendulum is given an initial condition $\dot{\alpha}(0) = \pi/2$ rad/s? Does your controller perform according to the design specification?

Part (iv): What is(are) the objective(s) of your controller? What is(are) the specification of your design? What is an extra state variable? Why do you need it? What is its purpose? What is it called? What are the system matrices A_i, B_i? How did you design your controller? What

assumption(s) is(are) made when you use a linear controller to control a nonlinear system? What is the motivation behind the poles location that you chose? Give the plots of position and angle of the cart, both from experiment and simulation using the best gain K. How are these plots generated? What are the settling times? Does your controller perform according to the design specification?

Discuss the general concepts of state feedback. What is state feedback? How does it change stability of a system? How is pole placement related to state feedback. Where should you place the poles? What is(are) the restriction(s) of poles location when the system is real? How are the real and imaginary part of a pole related to the system response?

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. Do your controllers meet the design specification? If not, recommend ways to improve the design methodology, or others design specification.

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 easily broken. So please do not suggest buying new gears. We also know that pole placement is a trial-error and a very tedious task.