EE411 Lab 3

1 Objectives

The primary objectives of this lab are:

- Familiarize student with the general setup of the ECP lab stations (this will save time in the future).
- Familiarize the student with the correlating real world data with modeling and simulation.

2 Getting Familiar with the General Setup of the ECP lab Station.

2.1 Safety

Familiarize yourself with section 2.3 Safety in the blue user's manual (pages 34-36).

2.2 The Setup for the Model 220 Servo Trainer Lab Station (Motor Gear Drive System)

Start the ECP program by finding the ECP32 icon on the Start/Programs menu on Win NT/Desktop.

Turn on power to the ECP lab station.

Under Setup, select the User Units to be counts

Use the Setup menu to locate and select Algorithm. When Algorithm is selected, select the following

Set control Algorithm to:

Type=Continuous Time

Control Algorithm=PID

Click on Setup Algorithm and set the constants Kp=0.05 Kd=0.0, Ki=0.0.

Select feedback to be from Encoder 1 and click OK

Select Implement Algorithm. This will load the algorithm into the ECP work station.

Click OK to close window

Select Trajectory from the Command menu.

Select a Step input as the reference input to the system. Setup the Step Size to 4000 counts with a Dwell time of 1000 msec. Number of repetitions is 1. It will be a closed loop step. Click OK to close the window. Click OK to exit Trajectory settings.

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2.3 Setting up the Plot

Select Data and Setup Data Acquisition from the menu. Use the Add Item buttons to add items to the plot. Choose the Commanded Position, and Encoder Position 1. Set the sample period to 2 Servo cycles. Click OK

Under Plotting, select Setup Plot. Using the Add to Left Axis button, select the Commanded Position and the Encoder 1 Position. Click OK.

Use Axis Scaling to zoom in and out on given portions of the plot for more accurate data recording.

2.4 Initializing the Lab Station

Under Utility, select Zero Position.

2.5 Running the Control

Choose Command, Execute (select Normal Data Sampling, if not checked), Run.

Plot the data using the Plotting menu. Include this plot with your report.

Measure the height of the first overshoot compared to the requested step.

Calculate Percentage overshoot __________%.

Measure the time duration between successive overshoots and record, convert this value to frequency also:

Time between successive overshoots_______ seconds, equates to a frequency of _________Hz.

2.6 Frequency Sweep

Set the PID parameters for Kp=1, Kd=.005. Set the trajectory for a sine sweep between 5 and 20 Hz, over a 30 second timespan, with an amplitude of 50 counts. This should be a closed loop linear sweep. Plot the encoder 1data with time along the horizontal axis and amplitude along the vertical axis. Does what you're seeing make any sense to you? Now replot the data with frequency along the horizontal axis and amplitude along the vertical axis. Does this make more sense? OK, now plot the magnitude in dB along the vertical axis and frequency along the x-axis (include this plot only). Explain what you're seeing in terms of the system.

2.7 Adjusting Parameters

Use a step trajectory as originally setup, but with a dwell time of 2000 msec. Make the PID parameters Kp=.2 and Kd=.005. Run the step response and examine a plot of the commanded position and the encoder 1 output.

Now adjust Ki to .5 and re-run the step (don't forget to re-implement the algorithm). Examine a plot of the commanded position and the encoder 1 output.

Can you explain the difference you see between the steady state values of the system for the controller with and without the Ki term.

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2.8 Experiment with Control Parameters

Try adjusting the control parameters for Kp, Ki, and Kd and observe the response to the step input. Include two plots with the reports, and state the Kp, Ki, and Kd values with the graph. Hint: don't make the changes too huge, or you'll exceed the system limits and will have to restart the controller. There should be a visible change in the system output response though.

3 Taking Data and Analysis

Use your numbers measured in section 2.5 above to do the analysis. The general form of the total (closed-loop) system is:

$$G(s) = \frac{Y(s)}{X(s)} = \frac{K\omega_n^{\ 2}}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

Where ζ is referred to as the damping factor. From the plot, ζ has the following relationship.

$$\%MaxOvershoot = 100e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}}$$

The "%MaxOvershoot is the peak of the first overshoot compared to the setpoint. This equation can be solved explicitly (as a quadratic), or iteratively using an "m file" or Mathcad or Excel.

The time necessary to complete one of the damped cycles is ω_d. This. ω_d is related to the natural frequency of the system by the following:

$$\omega_n = \frac{\omega_d}{\sqrt{1-\zeta^2}}$$

The (open-loop) **plant** (motor gear drive) has the transfer function of the form:

$$P(s) = \frac{K_m}{s(s+a)}$$

Knowing this, you can calculate the transfer function for the total (closed-loop) system and equate values to solve for Km and a.

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Include your work showing your calculation of the overall system transfer function, with a proportional gain controller, Kp.

Calculate Values for ω_n , K, ζ, Km and a from your collected Data and include them in the report.

4 Modeling the Lab in Matlab

Build a model of the system in Matlab Simulink using the parameters you have calculated. Run simulations of the model using the same step input and Kp parameters as in the lab. (Note: this is a modification of the simulink model you built in Lab 2).

Use matlab to perform a frequency sweep of your model using the same settings as the lab system. Plot the frequency magnitude (dB) versus frequency (linear) and compare to your experimental results.

Compare the results from the physical system and comment on any similarities or differences and their reasons for both the step input and the frequency sweep.

Include in your report, a copy of your model, and the response of the model to a step and sine sweep.

5 Remember To Turn Off Power To ECP Box When Finished.

Note: You may want to save the setup of the ECP controller to your Y: drive.

6 Writing the Report.

Please include the items listed above. Label each item, and number each item (including commentaries) according to its section.

Can you give a brief explanation for the use of a frequency sweep on an unknown (uncharacterized) system.