

Lab 3: SECOND-ORDER SYSTEM RESPONSE

Section 1 -- Background Information

In this lab we will construct a Simulink model of the closed-loop second-order torsion control plant. The model performance will then be compared to that of the actual plant. Since each ECP station has different characteristics, it is important that the same station used in Lab 2 be used for this procedure.

Section 2 – Procedure

2.1 Construct the Simulink Model

2.1.1 Construct the Simulink model as shown in Figure 1. Use the values for K_m and τ_m that were computed in Lab 2. For the Dead Zone block, enter the dead zone voltage, V_{DZ} determined from Lab 2. Assume the Dead Zone is symmetrical, and enter V_{DZ} as a positive and negative value in the Dead Zone dialog window. The Hardware Gain of 0.434 is a constant for all stations and is a property of the ECP hardware and software.[†]

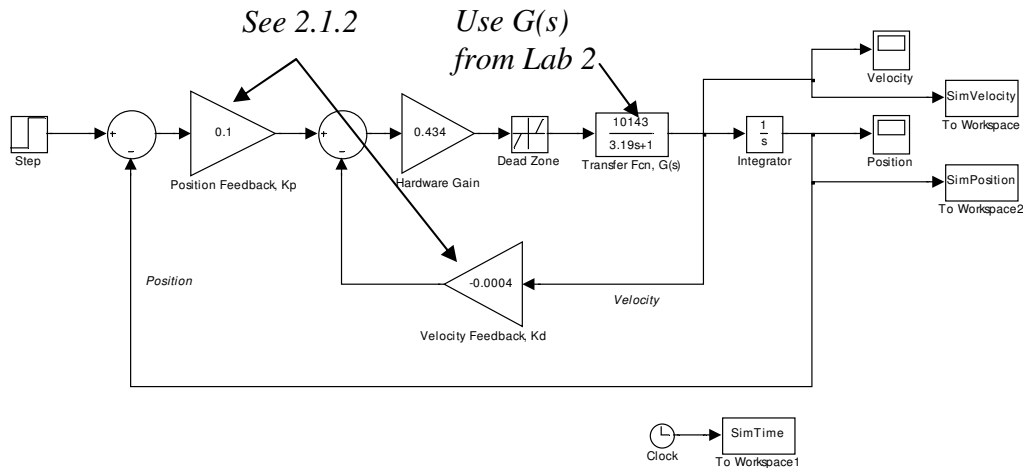


Figure 1. Simulink model of torsion control plant

2.1.2 In the Simulink model, set the Step input for 100 degrees. Next, determine some values for K_p and K_d that result in the following responses:

- Overdamped response. Set $K_p = 0.5$ and decrease K_d from 0.2 until an overdamped response is achieved and the response reaches 90% of the final value in less than 0.5 seconds.
- Underdamped response. Set $K_p = 0.5$ and increase K_d from 0.005 until a 10% overshoot is achieved.

2.2 Verify Model Results with the Real System

2.2.1 Start the ECP program.

2.2.2 Energize the control system by pushing the “ON” button on the ECP controller.

WARNING

The system is now energized and will rotate at potentially high speeds when a control voltage is applied to the motor of the torsion system. At any point the motion of the system can be stopped by pressing the OFF (red) button on the ECP controller box.

2.2.3 Setup the ECP Program

- a. Setup → User Units, select degrees
- b. Select Command → Trajectory
 - Select Impulse and Unidirectional moves. Click Setup.
 - Select Closed Loop Impulse and set Amplitude (degrees)=100; Pulse width (msec) = 5000; Reps = 1; Dwell Time (msec)= 0;

NOTE

To achieve a unit step input from the ECP program, we need to use the Impulse trajectory with a wide pulse width. The Step trajectory in the ECP program can not be used since it provides the equivalent of a square wave, where the negative going edge is not desired.

- c. Select Setup → Control Algorithm.
 - Select Continuous, then PI with Velocity Feedback
 - Click on Setup Algorithm. In the new window, enter the values for Kp and Kd used in 2.1.2. Also set Ki=0 and Feedback – Encoder 1.
 - Implement Algorithm, then click OK
- d. Select Data → Setup Data Acquisition
 - Sample Period (servo cycles) = 2
 - Selected Items should be Commanded Position and Encoder 1 Position
 - Click OK
- e. Reset encoders to zero (Utility → Zero Position)

2.2.4 Execute the ECP Program. Select Command → Execute, Normal Data Sampling. Click Run to load and execute the program.

2.2.5 Plot Data: Select Plotting → Setup Plot. For the left axis choose Encoder 1 Position and Commanded Position. Select Plot Data.

2.2.6 Export and save the raw data. In Matlab, plot the Simulink model results and the real data for comparison. Import the data into Matlab using the **load** command. Before you do this, you have to delete the column headings at the first row of the data file, as well as the square brackets in the beginning and end of the file prior to loading into Matlab. Use Notepad to do this. Be sure to note which column has the time and the position within this file. The position data is output as encoder counts so you will need to convert the data into degrees (360 degrees = 16,000 counts). Time is provided in seconds.

Section 3 -- Report

Submit a report in the standard format for this class. Discuss your observations of the Simulink model performance compared with the real system. Explain any differences observed between them. Comment on how the model might be modified or improved if necessary.

† The Hardware Gain, K_{HW} accounts for the various hardware and software gains utilized by the ECP system. K_{HW} is computed as shown below:

$$K_{HW} = K_e K_s K_c$$

where

K_e = encoder gain, 16,000 encoder counts / 360 degrees

K_s = controller software gain, 32 controller counts / 1 encoder count

K_c = DAC gain, 10 volts / 32,768 controller counts