

EE 4343 Industrial Control Systems

Homework Assignment 1

Asst. date: 26 April 2017 – Due date: 1 May 2017

Please email your solutions to me; we can go over them on Tuesday.

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You are asked to design a drive system for a good-sized load, driven by a DC servo motor via a gear train. This system will be constructed by combining the components on pages 10 and 12 of the Module 2 handout (prelim.pdf).

1. As a first step, develop the state-space model for this system, using the DC motor model in Fig. 10.13 (page 12 of prelim.pdf) *except* call the rotor moment of inertia J_1 and friction coefficient B_1 , and couple that to the load moment of inertia J_2 through a gear train as shown on page 10 of prelim.pdf. **Omit** K_1 in Fig. 5.26; (J_1, B_1) represent the servo motor mechanical part, just add the motor's circuit to complete the motor model. We are interested in the motion of the load, primarily.
 - (a) Based on independent energy storage considerations, what state variables do you need?
 - (b) Draw the complete schematic for this system (motor circuit and free-body diagrams).
 - (c) Derive the dynamic models based on this schematic.
 - (d) Solve for the state vector differential equations.
 - (e) Express the resulting state equations in $\dot{x} = Ax + Bu$ form (find A, B).
 - (f) As outputs, we are interested in the angular position and velocity of the load, $y = [\theta_2 \ \dot{\theta}_2]^T$, what is the output equation in the form $y = Cx + Du$?
2. As a second step, solve analytically for the equilibrium condition if the load torque τ_L in Fig. 10.13 (which is τ_{a2} in Fig. 5.26) is zero and input voltage e_i is a constant E_0 ;
 - (a) Case 1: find the equilibrium condition if K_2 is NOT zero
 - (b) Case 2: find the equilibrium condition if K_2 IS zero

Note that these two cases are fundamentally different ...