Linear Control of the QRC Wheel Flange Removal Machine

MECH 482

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California State University, Chico

Perry Cheney

Daniel Hanlon

Greg Reynolds

Allen Valdovinos

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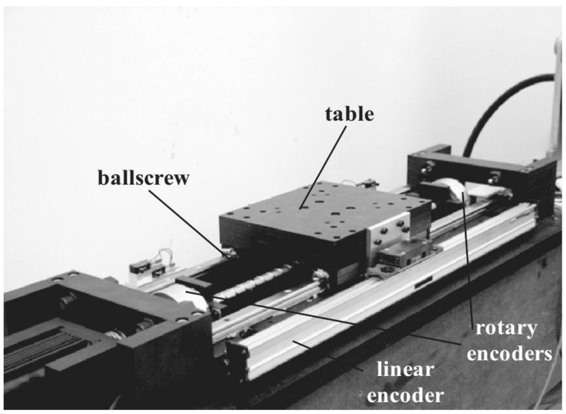
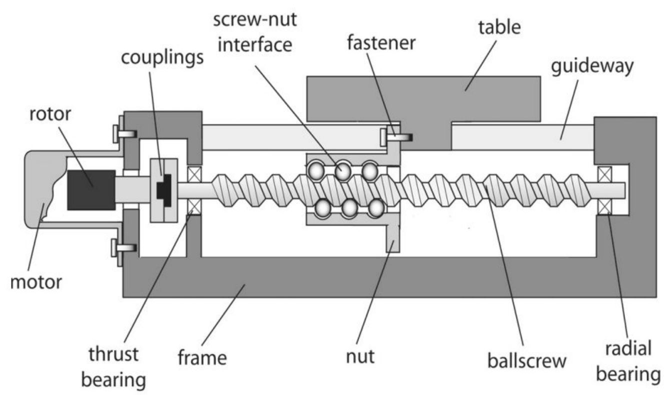
Introduction:
The linear position control project consists of a driven slide which moves along a track. The senior project being worked on by this group will utilize a similar mechanism to help remove a flange from a wheel. A mass at the end of the slide will represent the cutting tool used in the project. The team will investigate the mass and slide to test their algorithms. The group will be expected to create a mathematical model of the system with a designed control system. The following Figure 1 gives a sample high level architecture for the system.





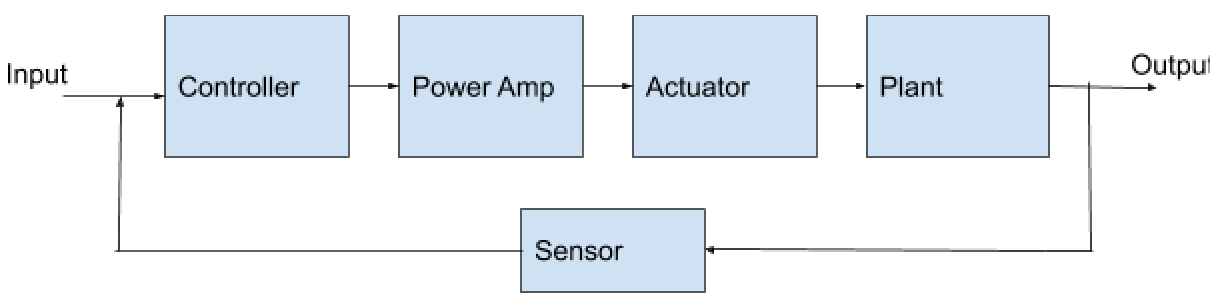


Figure 1: Sample High Level Architecture

Modeling:
A DC motor driven linear actuator with a mass on top was modeled by the following Figure 2. It considers and assumed inertia and damping of the motor. Data was assumed from comparison of specifications on the motor found on the PDF titled “MOTOR1_DS_1.pdf” to the motor that was given in problem 2.11 found in Skill assessment problem 2.11 of the textbook. A gearhead of 30:1 was accounted for in double reduction. The J load was assumed again from scaling off of what was given in skill assessment 2.11. The mass is treated as moving linearly with an added inertia and damping that the linear drive’s rod is experiencing.

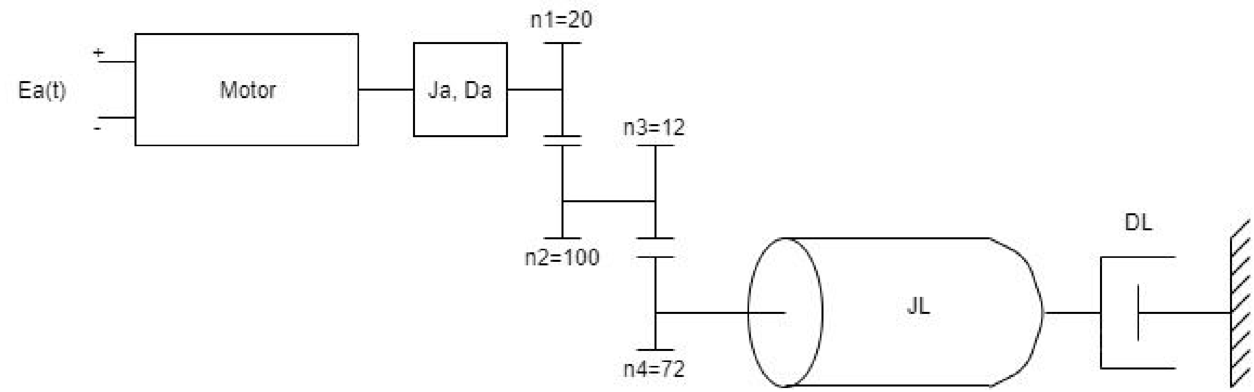


Figure 2: Model of a DC Motor Driven Linear Actuator with Mass

The following equations show the process followed to reach a transfer function for the system model. This transfer function was used in Simulink and VRep to simulate the system.

$e_a = 12v \quad T_{stall} = \quad W_{NoLoad} = 200RPM = 20.94Rad/s \quad J_a = .001Kg/m^2$
$D_a = .2Nms/rad \quad J_L = 4Kg/m^2 \quad D_L = 5\ Nms/rad$

$$\frac{K_R}{R_a} = \frac{T_{Stall}}{e_a} = .029167 \quad K_B = \frac{e_a}{W_{NoLoad}} = .5731$$

$$J_{eq} = J_a + J_L(\frac{n_1}{n_2} * \frac{n_3}{n_4})^2 = 0.00544\ Kg/m^2$$

$$D_{eq} = D_a + D_L(\frac{n_1}{n_2} * \frac{n_3}{n_4})^2 = 0.2056\ Nms/rad$$

$$\frac{\theta_m(s)}{E_a(s)} = \frac{\frac{K_T}{R_a * J_{eq}}}{s[s+\frac{1}{J_{eq}}(D_{eq}+\frac{K_T * K_B}{D_a})]}$$

$$\frac{\theta_m(s)}{E_a(s)} = \frac{5.632}{s[s+40.867]}$$

$$\frac{W_m(s)}{E_a(s)} = \frac{\theta_m(s)}{E_a(s)} * s = \frac{5.362}{s+40.867}$$

To go from the given transfersition function of theta (position) over the voltage input, to the omea (velocity) over the voltage input and derivative of the position has to be taken which is why the equation needs to be multiplied by s. As a result, the s cancels out.

Simulation:
The following block diagram seen in Figure 3 was constructed in Simulink using the transfer function found above. The block diagram was constructed such that the desired position was .2 meters.

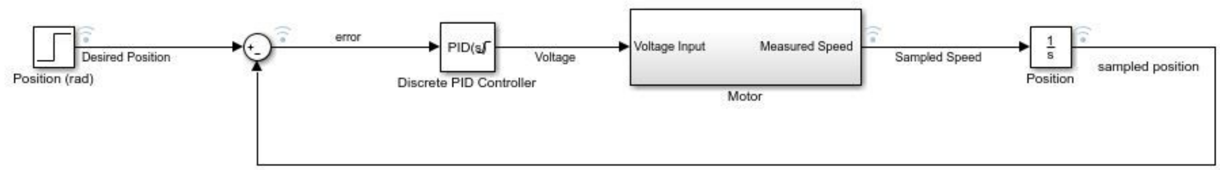


Figure 3: Simulink Block Diagram

The following Figure 4 are the results of the Simulink block diagram. The y-axis represents position in meters and the x-axis represents time in seconds. As can be seen from the plot, the input is applied at .5 seconds, changing the desired position from 0 meters to .2 meters at that time. This is represented by the orange line. The blue line is the DC motor response in velocity. The resulting speed of the motor will result in the desired distance.

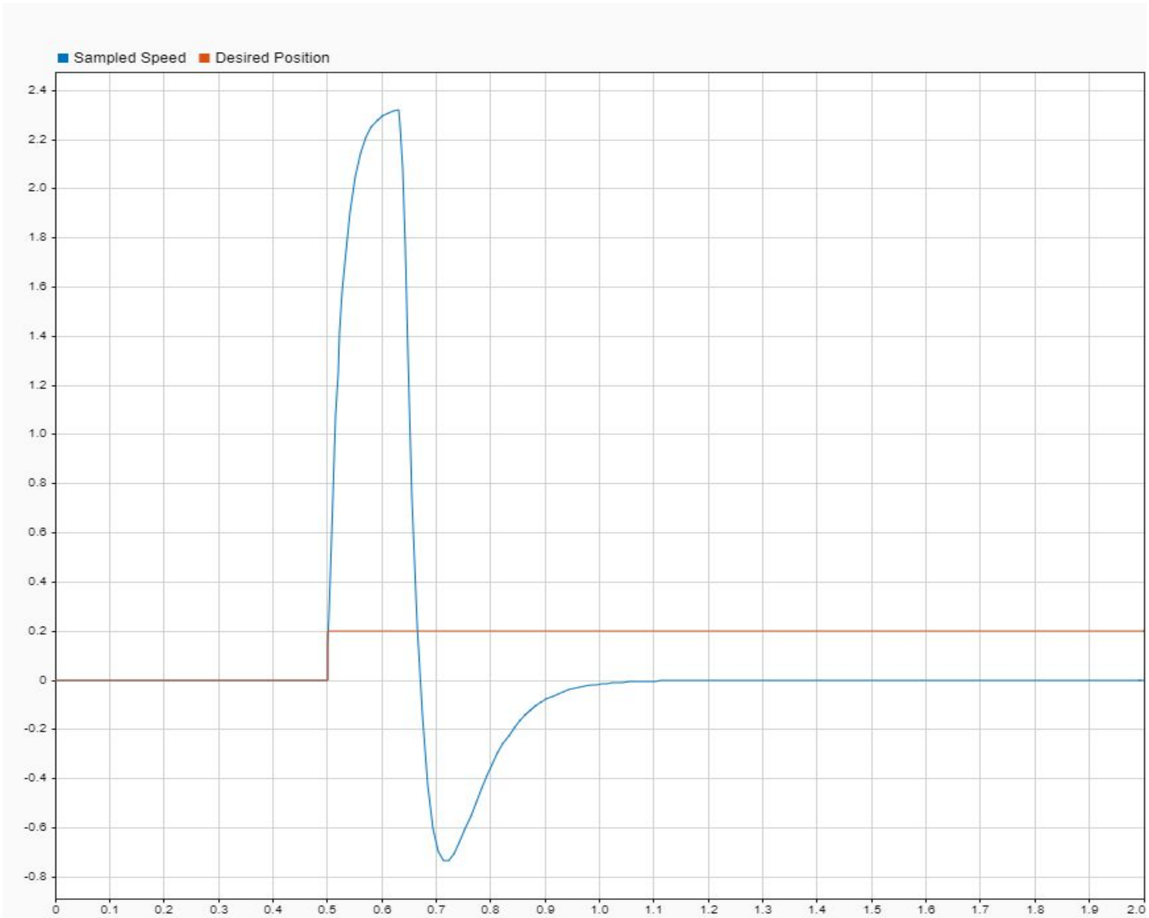


Figure 3: Simulink Results from Block Diagram Simulation