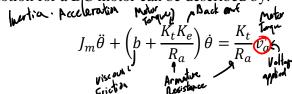
Robotics and Control Laboratory ECSE 493 W2017 Lab Assignment 1

Analysis and Simulation of a Servo System

Due January 27th by 4pm. Please upload your assignment to the class webpage

This assignment is a review. I will try to upload some review notes by Monday.

1. The equation of motion for a DC motor can be described by:



where

 θ is the shaft angle (in radians) of the motor and v_a is the applied voltage. Let

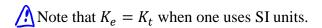
 $J_m = 0.01 \text{kgm}^2$ be the inertia of the rotor and the shaft

b = 0.001 Nmsec be the viscous friction coefficient

 $K_e = 0.02$ Vsec be the back emf constant

 $K_t = 0.02 \text{ Nm/A}$ be the motor torque constant

 $R_a = 10\Omega$ be the armature resistance



- (a) Find the transfer function between the applied voltage and the speed of the motor shaft. (Plug in the numbers above).
- (b) Repeat part (a) but use the Matlab command *tf* and the values above to define a transfer function between the applied voltage and the speed of the motor shaft. Use the step command to estimate the steady-state speed of the motor after a voltage is applied.
- (c) Use the step response plot to estimate how long it takes the motor to reach within 1% of steady state angular velocity.
- (d) Look up the Final Value Theorem and calculate the steady state speed of the motor after a voltage is applied. How close was your graphical estimate of the final value?
- (e) Find the transfer function between the applied voltage and the shaft angle.
- (f) Apply feedback to the transfer function in (d). Draw a block diagram of the system. Add a gain of K to the forward path of your block diagram. What is the transfer function of the feedback system?
- (g) What are the units of K?
- (h) What is the input into the motor? (i.e., what is the applied voltage?)
- (i) Find the transfer function between v_a and θ . (The system is now a position servo).
- (j) What is the maximum value of K that can be used if an overshoot of Mp<20% is desired?

- (k) What value of K provides a rise time of 4 seconds (ignore overshoot constraint above).
- (l) Plot the step response of the position servo for K=0.5, 1 and 2 and use the plots to find the rise time and % overshoot for each value of K.
- (m) What feature of the step response is K controlling?

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2. Enter the following in Matlab; p=[1 1]; q=[1 5 6 0]; sys=tf(p,q); rlocus(sys);
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-these commands will produce a Root Locus plot.

- a) What are p and q?
- b) Define and explain the function of the root locus. What is being depicted in the root locus plot of the system defined above?