EE380 (Control Systems) Pre-Lab work of Experiment 5

Student Name	Roll No.	Bench No.

You should use your values of R_Σ, B, K_t, K_b, J, etc in the m-files `e5q4.m` and `e5q5easysim.m`.

Q1 Using the voltage equation $V = L\frac{di}{dt} + Ri + E$, the fundamental torque equation $J\frac{d\omega}{dt} = -B\omega + T - T_L$, $E = K_b\omega$, and $T = K_t i$, determine the current at steady-state speed with $V = 7$ V and $T_L = 0$. Call this current i_{d1}. See the lecture slides.

Note: The figure i_{d1} is the maximum value that we wish to specify as reference for the current control at $T_L = 0$. Any greater value of reference current at $T_L = 0$ will require the H-bridge to apply a voltage $V > 7$ V, and thereby go into voltage saturation. We wish to avoid saturation so that we may work with an approximately linear plant.

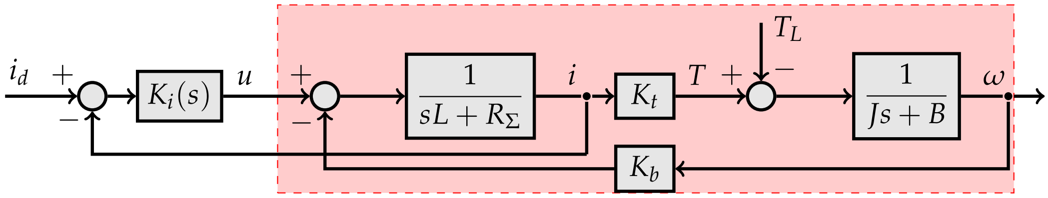
Q2 Using the voltage equation, the fundamental torque equation, $E = K_b\omega$, and $T = K_t i$, determine the current at steady-state speed with $V = 7$ V and $T_L = 0.003$ N $\cdot$ m. Call this current i_{d2}. See the lecture slides.

Note: This value of $T_L = 0.003$ N $\cdot$ m has been arrived at as follows. The radius of the pulley where the string winds is approximately $r = 1.25$ cm. The mass of the load is in the range $m = 1.5 - 2$ kg, but we assume that it is 1.5 kg. Acceleration due to gravity $g = 9.8$ m/s^2. The gear ratio is $R_g = 62$. Then, $T_L = mgr/R_g \approx 0.003$. *But wait!* Don't we need to divide the answer by the efficiency of the gear $\eta \approx 0.59$? Then, $T_L \approx 0.005$ N $\cdot$ m.

Note: This i_{d2} is the maximum value that we wish to specify as reference for the current control at $T_L = 0.003$ N $\cdot$ m. Any greater value of reference current at $T_L = 0.003$ N $\cdot$ m will require the H-bridge to apply a voltage $V > 7$ V, and thereby go into voltage saturation. We avoid saturation to have an approximately linear plant. The minimum value of i_{d2} is T_L/K_t. When we apply the load and require the motor to track a value of i_d that is less than this minimum value of i_{d2}, the load will drive the motor, rather than the motor driving the load.

Q3 Determine the TF from u to i for the PMDC motor in preparation for the design of a proportional-integral (PI) controller. Use the values of R_Σ and B from the experiment where they were calculated from the experimentally-deterimined K_m and τ_m.

The armature inductance L_a is negligible (see footnote in lab manual, Ch. 2).



Plant: The part outside dsPIC30F4012

Q4 We wish to work out a controller $K_p + K_I/s$ with the best settling time we can achieve for the <u>unloaded motor</u>, while keeping the control effort u out of saturation. Provided to you is an m-file `e5q4.m` for this purpose. Run this m-file and document in the table the effect of varying K_p and K_I.

Values of (K_p, K_I)	$(20,0)$	$(250,0)$	$(250,100)$	$(20,100)$	$(20,500)$	$(20,1500)$	$(0,1500)$
Approx. settling time t_s [s]							
Tracking error $e_{0+} = i_d(0+) - i(0+)$ [A] using intial value theorem $\lim_{t\to 0+} y(t) = \lim_{s\to\infty} sY(s)$							
Tracking error $e_0 = i_d(0+) - i(0+)$ [A] from plot							
Steady state error e_{ss} [A]							
Max. control effort [V]							

Q5 Provided to you is `e5q5easysim.m`, which is a modified version of `easysim.m`. Simulate the CL system of the above figure for $i_d = i_{d1}$ and fill the below table.

Values of (K_p, K_I)	$(20, 0)$	$(250, 0)$	$(250, 100)$	$(20, 100)$	$(20, 500)$	$(20, 1500)$	$(0, 1500)$
Approx. settling time t_s [s]							
Tracking error $e_{0+} = i_{d1}(0+) - i(0+)$ [A]							
Steady state error e_{ss} [A]							
Max. control effort [V]							

Q6 Do the results of Q5 match those from Q4? Explain the differences. (Hint: A thought on the two questions asked in `e5q4.m` might reveal the answer).

Q7 With $T_L = 0.003$ N $\cdot$ m and $i_d = i_{d2}$, perform a simulation of the digital control of the motor using `e5q5easysim.m` and the controllers from the above tables. Write down a controller that you will use in the lab.