6.302 Lab 1A Report

Michael Salib

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I used motor station 2 for the experiments with the flywheel and station 8A for experiments without the flywheel. I worked alone.

R_m	8.78 ohms
L_m	0.00663 henries
K_e	$0.0217\, Volts \times Seconds$
K_{tach}	$0.0273\, Volts \times Seconds$
J_m	$3.56 \times 10^{-6} Kilograms \times Meters^2$
J_f	$2.74 \times 10^{-5} Kilograms \times Meters^2$
n	6.75
K_t	$0.0218 \frac{Newton \times Meters}{Amps}$
K_p	3.23 Volts

1 Measurements

I.1. The discontinuity across θ_p is 20.31 V.

I.2. I recorded the following data.

V_m (V)	I_m (mA)	$\dot{\theta}_m$ (V)	Δt (ms)
-1.030	-64	-0.515	2,275
-3.047	-56	-3.10	378
-5.05	-63	-6.21	185
-7.54	-67	-8.58	134.5
-9.994	-74	-11.65	100

I.3. I recorded the following data. Note that $i = \frac{I_m}{2}$.

I_m (A)	$\ddot{\theta}_m$ (V/s)
0.200	2.02
0.603	6.08
0.987	9.46
1.403	13.43
1.800	17.57
2.188	21.35
2.610	25.76
3.031	28.93
3.281	31.08

II.1 I recorded the following data.

Δv (V)	Δi (A)	t_r, rise time (ms)
1.437	0.05	1.6
3.250	0.273	1.52
5.50	0.413	1.730
7.437	0.869	1.780
9.375	1.156	1.690

II.2 I recorded the following data.

Δv (V)	t_r, rise time (ms)
2.00	108
4.25	104
6.19	96
7.94	96
9.80	96

II.3 I recorded the following data.

I_m (A)	$\ddot{\theta}_m$ (V/s)
0.180	13.90
0.319	28.35
0.622	53.76
0.937	74.43
1.187	99.73

2 τ_m Calculation

Dividing the $\dot{\theta}_m$ rise time measurements from part II-2 by 2.2 gives the motor time constant, because

$$\frac{\dot{\theta}}{V_m} = \frac{K_t}{Js(R_m + sL_m) + K_t K_e}$$

Since we're applying a step voltage input and measuring $\dot{\theta}$ in part II-2, this equation describes the response. Because L_m is small, the pole associated with the motor's electrical response is at a much higher frequency than the pole associated with the motor's mechanical response. The motor's behavior is thus dominated by its mechanical time constant, $\tau_m = \frac{J_m R_m}{K_t K_e}$. Since the motor's behavior is dominated by its mechanical time constant (to a first order approximation), measuring the rise time of the motor's response to a step voltage input gives a good approximation for τ_m.

3 Questions

1. I measured a value of $\tau_m = 0.045$ in the lab. Using the formula from the prelab with the other parameters measured in lab, I calculate that $\tau_m = 0.066$. The measured value is close, but not identical to the calculated value.

2. K_t and K_e are the same, within experimental error. Conservation of energy requires that the total mechanical power equal the total electrical power, $I_m V_m = T\dot{\theta}$. Rearranging terms, we have, $\frac{T}{I_m} = \frac{V_m}{\dot{\theta}}$, but we know that $K_e = \frac{V_m}{\dot{\theta}}$ and that $K_t = \frac{T}{I_m}$. Therefore, $K_t = K_e$.

3. The inertia of the flywheel is at least ten times larger than the inertia of the big gear since the big gear's inertia is subsumed in the motor's inertia. We know that the flywheel's inertia should be n^2 times the big gear's inertia since the gear ratio is $n = 6.75$. Thus, we expect the flywheel to have an inertia 45 times larger than that of the big gear.