Lab 8 - Motor Characterization

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1 Introduction

Hmmm...hi, I'm Jiaying, and today I'm here to tell you how the electrical domain and the mechanical domain of our motor is related. I could put some stuffs about what I learned about this lab, but I think the sections below do a much better job than this intro could ever hope to do.

2 Prelab

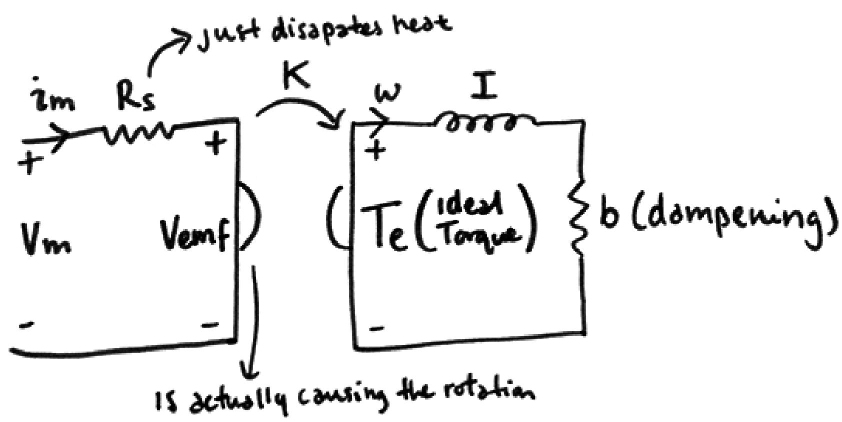


Figure 1: Electrical and mechanical domainssssss.

R_s or the motor series resistance, is the resistance the motor normally has without all that extra turning.
K or the motor constant, is how V_{emf} is related to T_e.
I or the moment of inertia, is how much our motor resist acceleration.
b or the linearized motor losses, is essentially dampening caused by the motor resisting movement cause it has a chunk of huge ass plastic mounted onto it.

3 Build time

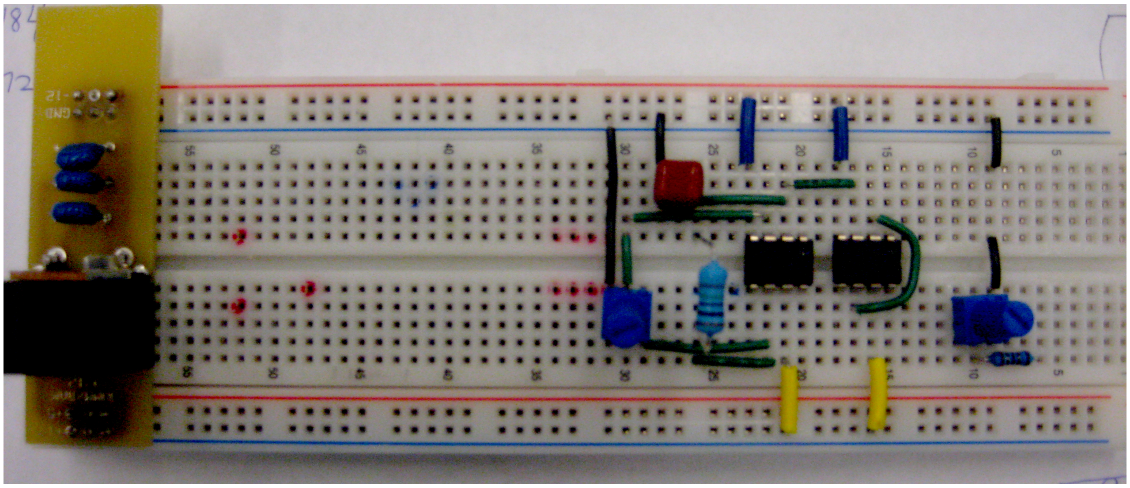


Figure 2: What I built.

4 Lab time

4.1 Series Resistance

I measured my series resistance which is the amount of resistance the motor has naturally without moving. It turns out $R_s = 22.9\Omega$

4.2 Motor Constant

Lower Voltage

Finding V_{emf}

$$\begin{aligned} R_s &= 22.9\Omega \\ V_m &= 1.30V \\ i_m &= .0048A \\ V_{emf} &= V_m - i_m R_s = 1.19V \end{aligned}$$

Finding w (angular velosity)

$$\begin{aligned} Revolutions &= 30 \\ Totaltime &= 28.327s \\ w &= 6.65rad/s \end{aligned}$$

Finding motor constant K

$$K = \frac{V_{emf}}{w} = 0.179V \cdot s$$

Higher Voltage

Finding V_{emf}

$$\begin{aligned} R_s &= 22.9\Omega \\ V_m &= 4.42V \\ i_m &= .0041A \\ V_{emf} &= V_m - i_m R_s = 4.42V \end{aligned}$$

Finding w (angular velosity)

$$\begin{aligned} Revolutions &= 30 \\ Totaltime &= 11.112s \\ w &= 16.96rad/s \end{aligned}$$

Finding motor constant K

$$K = \frac{V_{emf}}{w} = 0.26V \cdot s$$

My K values for my lower and higher V_{in}s are different, which Forest says is suppose to happen, so that's good. We will agree that V_{emf} is to T_e as i_m is to w. $\frac{V_{emf}}{i_m} = \frac{T_e}{w}$ and K is the proportionalitly constant, therefor it makes perfect sense that I use $V_{emf} = Kw$ in order to find my motor constant.

5 Time Constant

I found the time constant for the motor by taking the voltage of my motor from the oscilloscope. I would find the change in voltage in the motor and then take 63% of that. I would then search in my matrix for the first matching voltage, find the Δt from the original time.

$$\tau_{noload} = 0.484s$$
$$\tau_{loaded} = 5.372s$$

5.1 Motor losses and moment of inertia

So because we accept the truth that $\sum T = I\dot{w}$ (which totally is just the torque formula, remember w is just velocity so $\dot{w}$ is acceleration).

$$\begin{aligned}
V_{emf} &= Kw \\
w &= \frac{V_{emf}}{K} \\
\sum T &= I\dot{w} \\
T_e &= I\dot{w} + bw \\
Ki_m &= \frac{I}{K}\dot{V_{emf}} + \frac{b}{K}V_{emf} \\
i_m &= \frac{I}{K^2}\dot{V_{emf}} + \frac{b}{K^2}V_{emf}
\end{aligned}$$

Because we know that $i = \frac{V}{R}$, $\frac{K^2}{b}$ is a resistor. If we go back to lab3 - Oscillator, we'll find that $i_m = C\dot{V_{emf}}$ can be mathed around to $V = \frac{1}{C}\int i\ dt$ which is totally the capacitor formula. Holy squids! This is an RC circuit...which means $\tau = RC$ is true!

$$\begin{aligned}
\tau &= RC \\
R &= \frac{K^2}{b} \\
C &= \frac{I}{K^2} \\
\tau &= \frac{K^2}{b} \cdot \frac{I}{K^2} = \frac{I}{b}
\end{aligned}$$

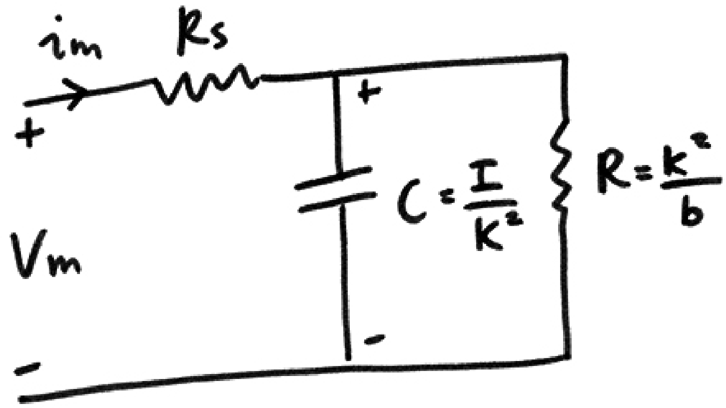


Figure 3: ooooo, ahhhhh

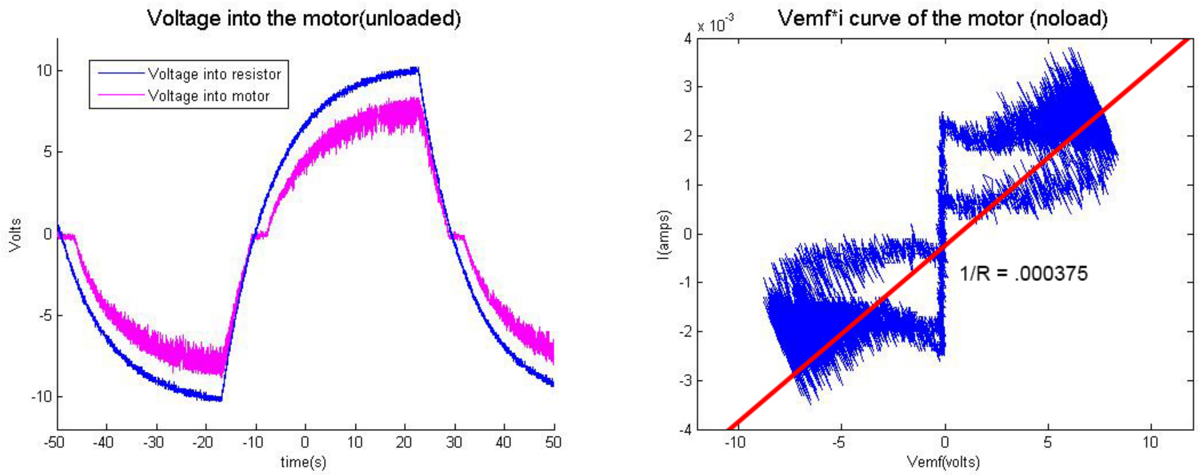
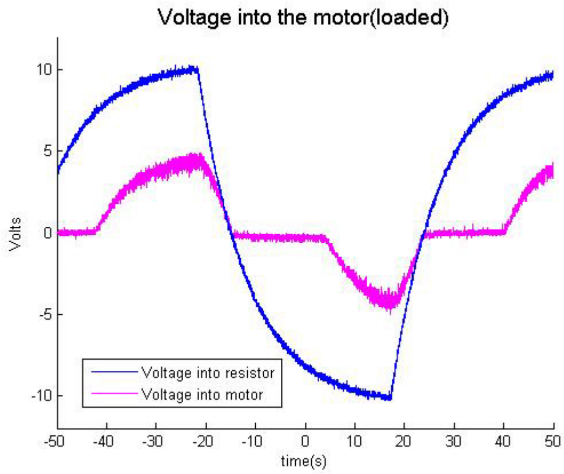


Figure 4: We find the resistance of resistor by taking the slope

Calculating b_{noload} and I_{noload}.

$$R = \frac{K^2}{b} = 2666\Omega$$
$$K = 0.26V \cdot s$$
$$b_{noload} = 2.53 \times 10^{-5}$$

$$\tau_{noload} = 0.484 = \frac{I_{noload}}{b_{noload}}$$
$$I_{noload} = 1.23 \times 10^{-5} kg \cdot m^2$$



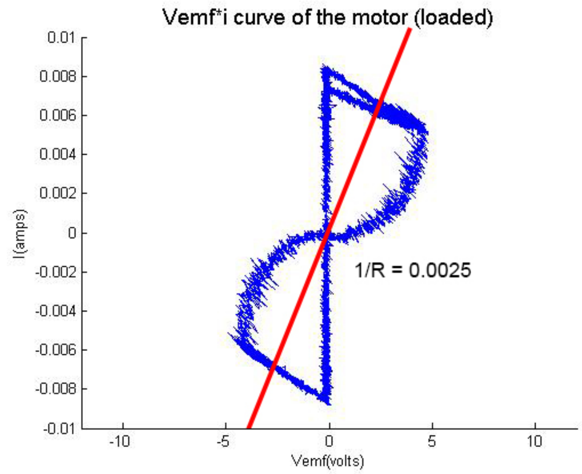


Figure 5: Dayum this motor be loaded.

Calculating b_{loaded} and I_{loaded}.

$$R = \frac{K^2}{b} = 400\Omega$$
$$K = 0.26V \cdot s$$
$$b_{loaded} = 1.69 \times 10^{-4}$$

$$\tau_{loaded} = 5.372 = \frac{I_{loaded}}{b_{loaded}}$$
$$I_{loaded} = 9.08 \times 10^{-4} kg \cdot m^2$$

Inertia is greater when there's a huge chunk of delrin on my motor...sounds pretty reasonable.