Lab 8: Motor Characterization

Ruby Spring

November 11, 2013

Abstract

This lab explores the mechanical domain by characterizing a Lego motor. To characterize the motor we used the perfect analogy of electrical to mechanical, and drew our equations accordingly from the analogy.

1 The Motor

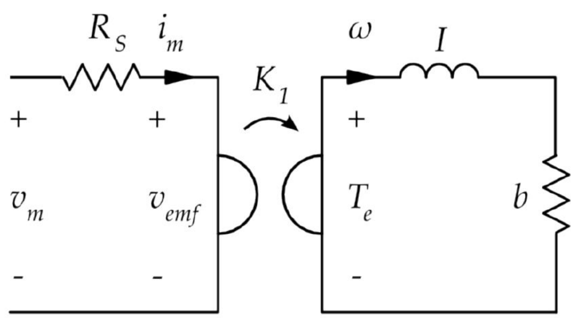

Figure 1: Motor Diagram

The model of the motor shows the analogy between the electrical and mechanical domain. The electrical domain in the motor consists of a series resistor with current i_m. The current is analogous to w, the rotational speed of the motor, which is determined by the motor constant K. The moment of inertia, I, is represented by an inductor and b represents the losses of the motor.

2 Resistance of the Motor

The series resistance of the motor was measured using a multimeter to be 23Ω.

3 Finding K

The motor constant K can be found using the equation $K = \frac{V_{emf}}{w}$. V_{emf} can be determined by the equation $V_{emf} = i_m R_{motor}$, where i_m is found by calculating the current through a known resistance in series with the motor. w can be found simply by counting the RPM of the motor and converting accordingly. The first trial produced $8.7965\frac{r}{s}$ and an average V_{emf} of $9.1869E-5$. The second trial produced $19.6873\frac{r}{s}$ and an average V_{emf} of $2.1077E-4$. The average value of K is determined below:

$$K_1 = 1.0444E - 5\text{Volt seconds} \tag{1}$$
$$K_2 = 1.0706E - 5\text{volt seconds} \tag{2}$$

$$K_{avg} = \frac{K_1 + K_2}{2} = 1.0573E - 5\text{volt seconds} \tag{3}$$

4 Finding the Time Constant

To find the time constant, τ, we simply use the graph to look find the time it takes the motor reach steady state.

4.1 No Load

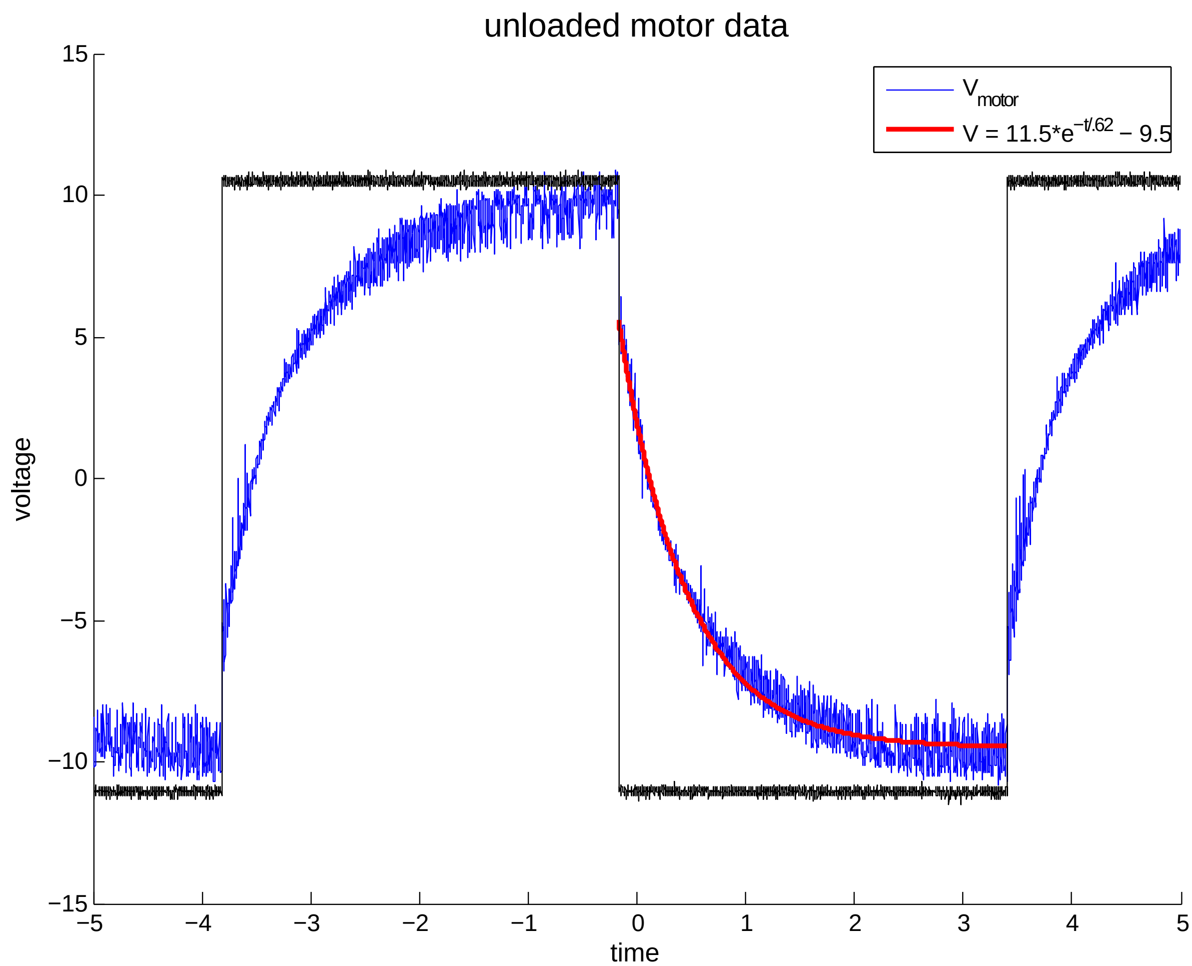

Figure 2: Timestep of the motor with no load.

With no load, the motor reaches steady stack in about 3.5 seconds. I don't know why it was important to fit the exponental curve to the data, but the equation for the curve is as seen below:

$$V_{emf} = 11e^{\tau/.62} - 9.5$$

4.2 Loaded

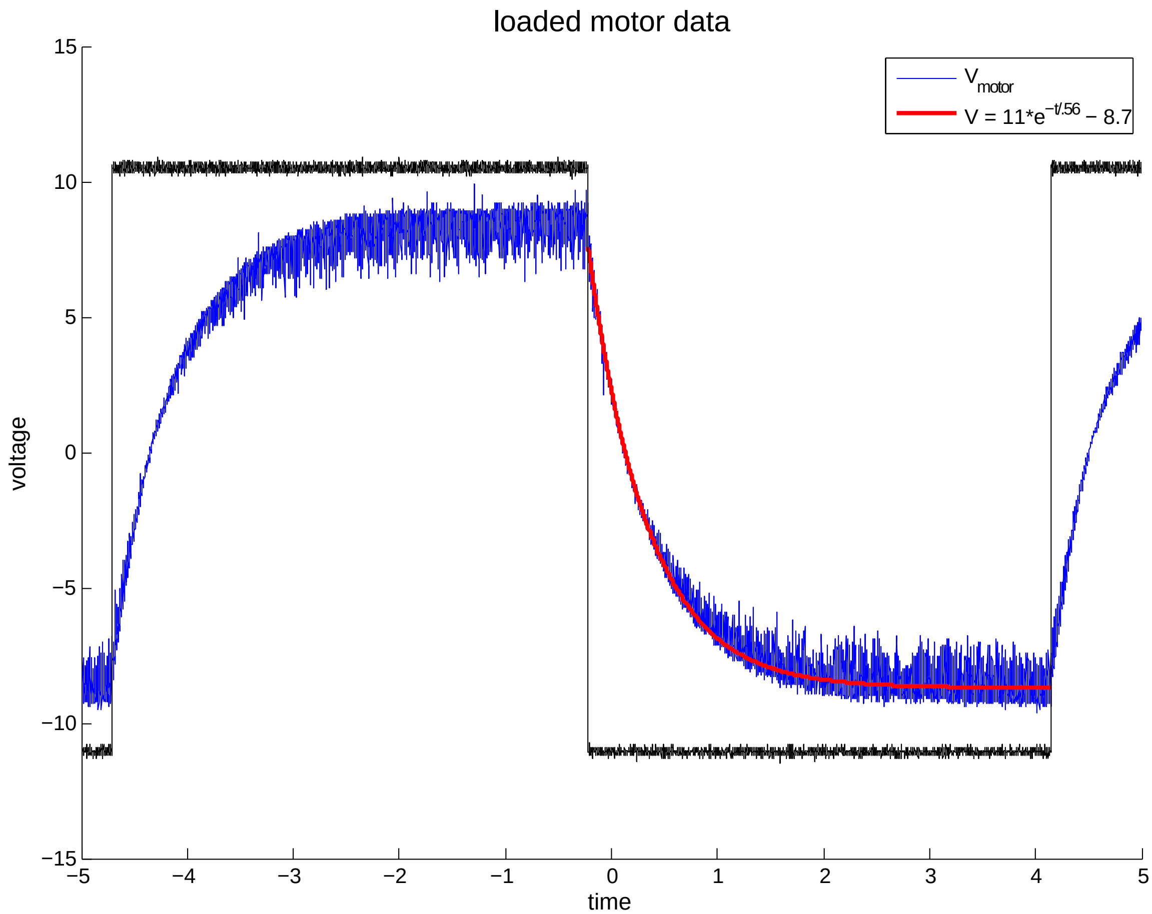

Figure 3: Timestep of the motor with a load

With a load, the motor reaches steady state more slowly, about 4.5 seconds. The equation for the curve is:

$$V_{emf} = 11.5e^{\tau/.56} - 8.7$$

5 Motor Losses and Moment of Inertia

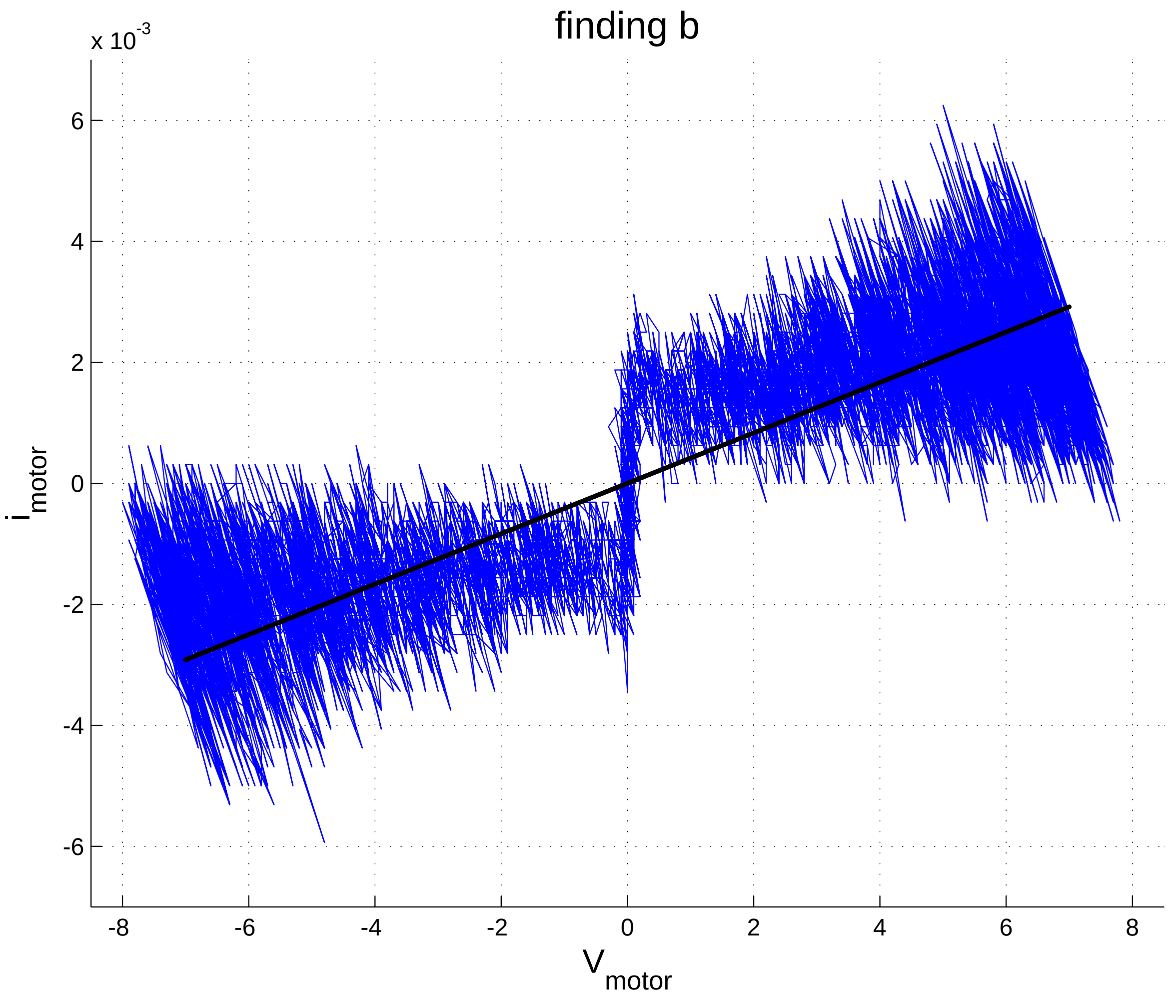

Figure 4: vi curve of motor with no load

$$\frac{V_{emf}}{i_m} = \frac{b}{K^2} = 4.1667E - 4 \tag{4}$$

$$b = 1.8631E - 14 \tag{5}$$

$$I = \tau b = 6.5210E - 14 \tag{6}$$

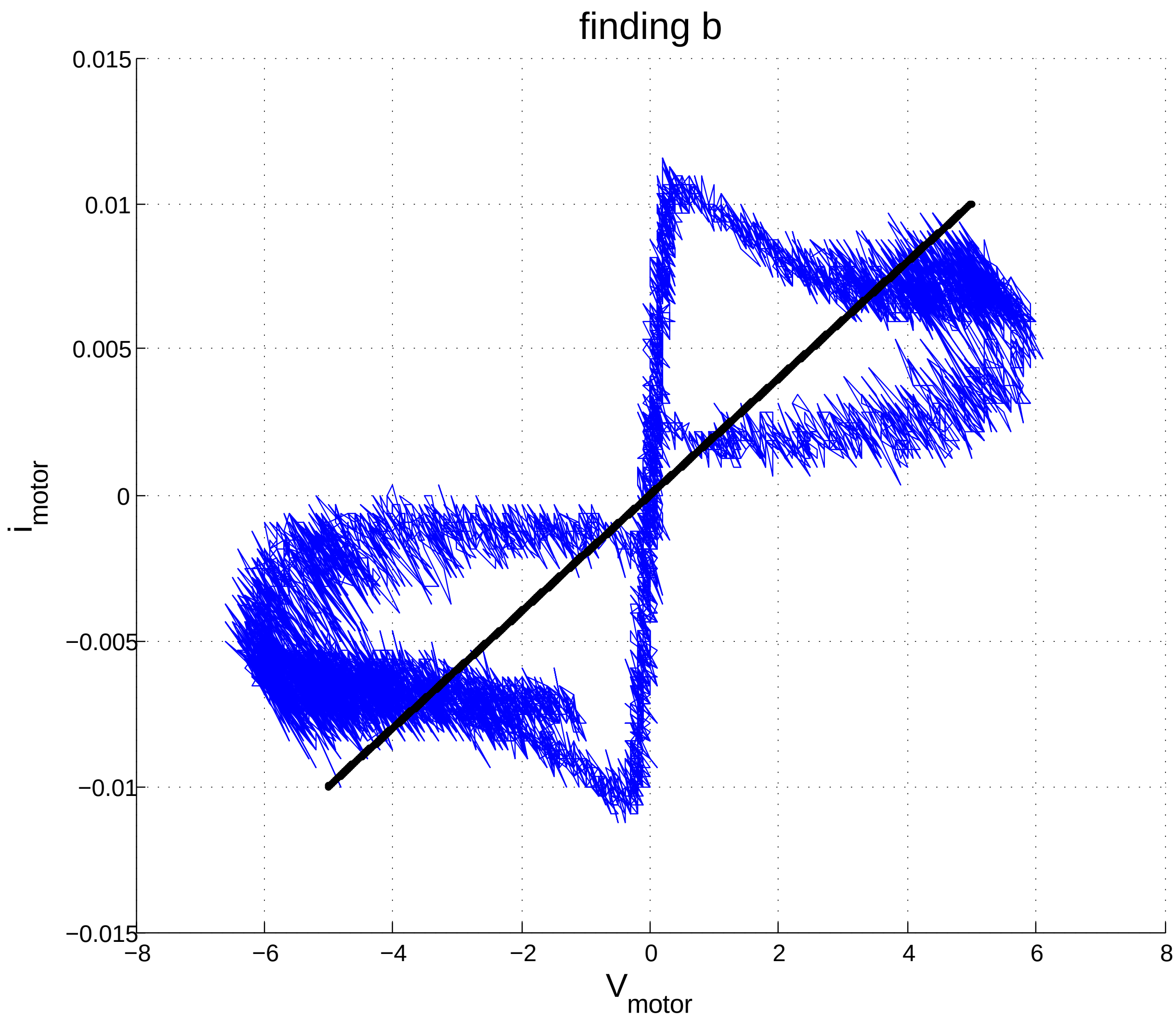

Figure 5: vi curve or motor with load

$$\frac{V_{emf}}{i_m} = \frac{b}{K^2} = .0050 \tag{7}$$

$$b = 5.5894E - 14 \tag{8}$$

$$I = \tau b = 2.5152E - 12 \tag{9}$$

It makes sense that the value of I is greater with the load because higher inertia is analogous to higher inductance. Hurray!