The University of Georgia

ELEE 4220/6220: Sensors and Transducers

Lab 2 – Spring 2025 – Individual

Emerson Hall

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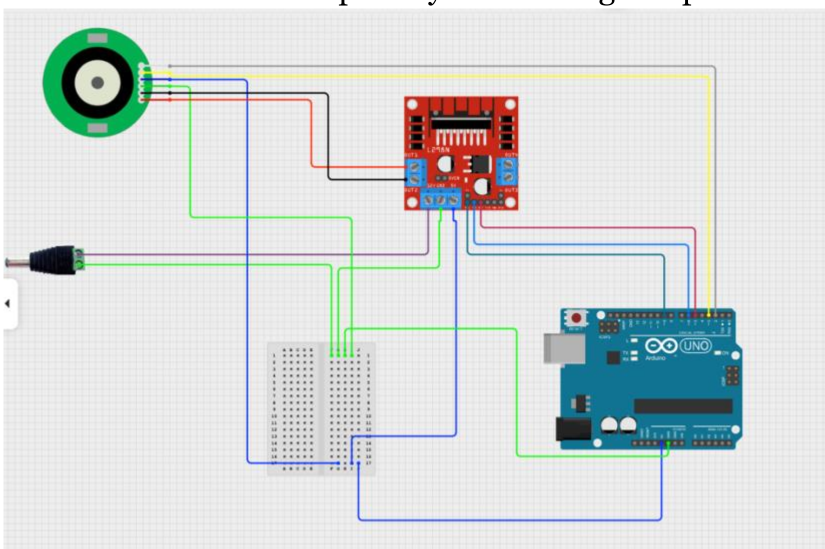
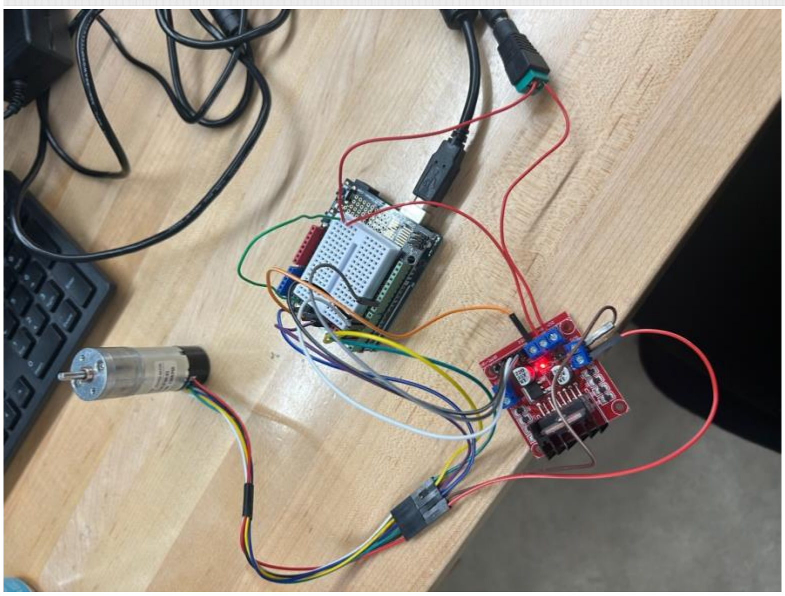
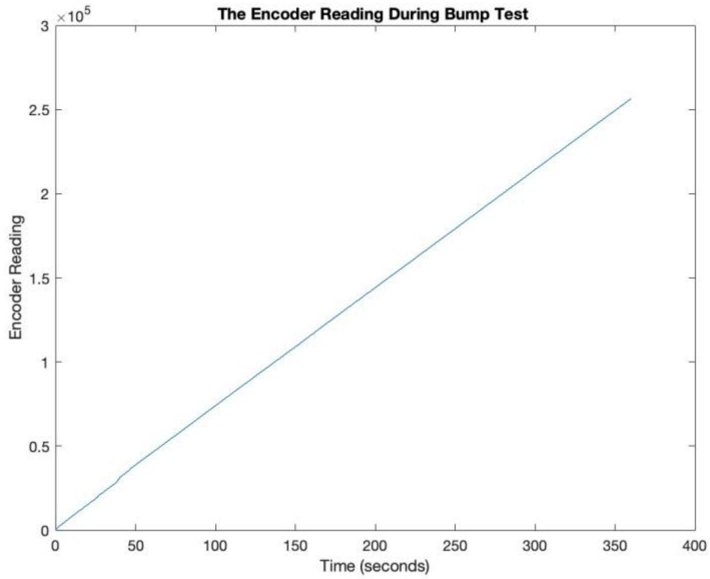
Lab 2: Servo Motor Setup

Deliverables

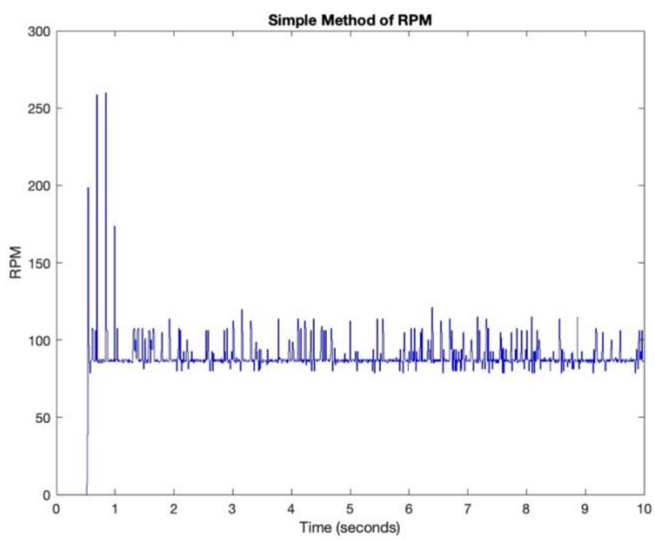
1. The first deliverable is to create a wiring a diagram of your setup. Use an electronic tool. Also include a photo your working setup.
    a. 

    b. 
2. Get the encoder reading and plotting data. You can implement a bump test. Have the microcontroller send a constant voltage to the motor and then get the encoder counting angle.

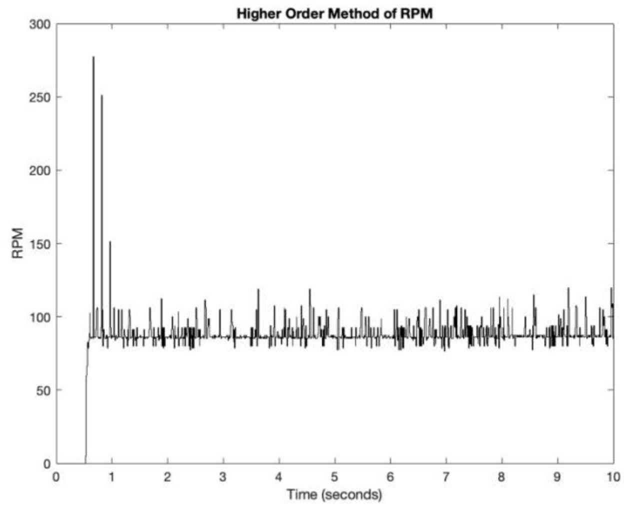


a.

3. Update the code to calculate RPM (https://ctms.engin.umich.edu/CTMS/Content/Activities/figures/speed1.png). We will need to calculate the derivative. Before doing this, read this article: https://en.wikipedia.org/wiki/Numerical_differentiation.
    a. Do the simple finite difference method.

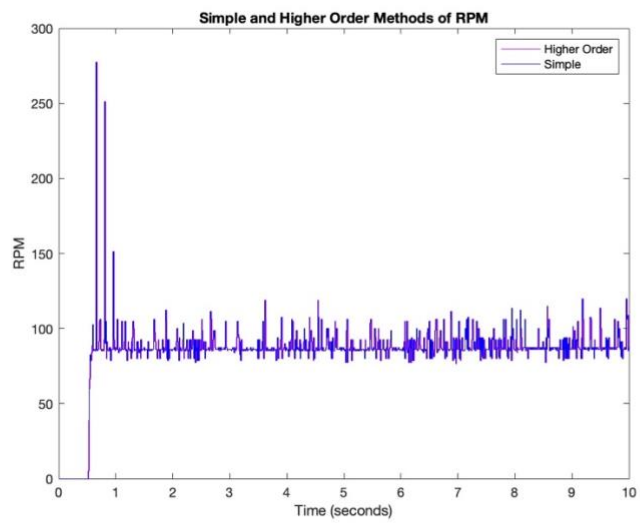


        i.
    b. Implement a higher order method.



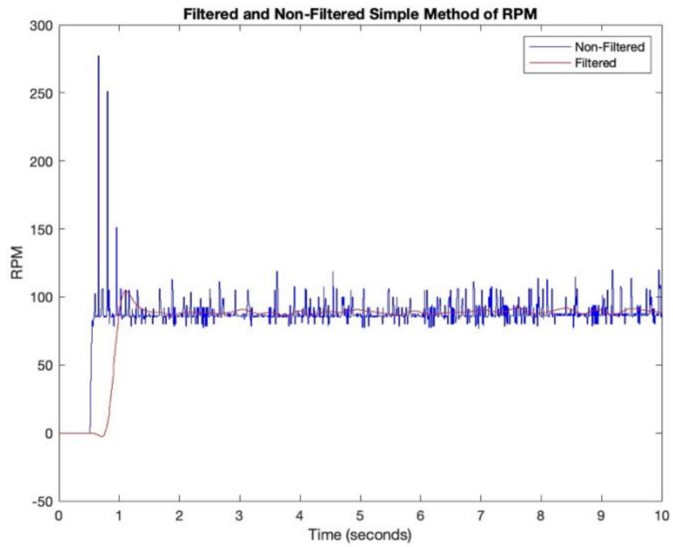
i.

c. Place both on a plot and compare.

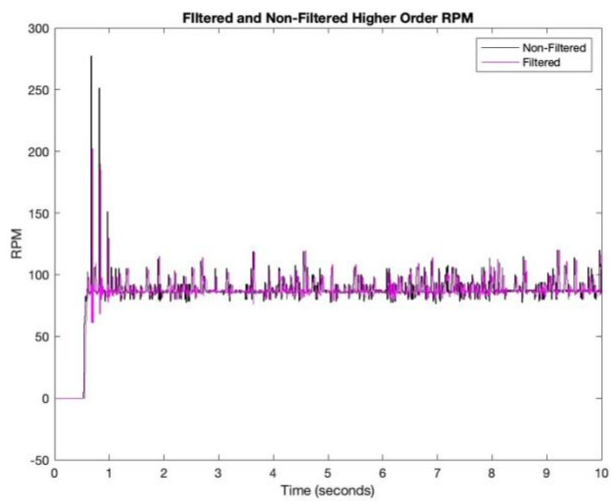


i.

4. Adding a filter. Use a prepacked library (unless you'd like to write your own code) to add a low-pass filter.
   a. Include a graph similar to https://ctms.engin.umich.edu/CTMS/Content/Activities/figures/speed1.png.



i.



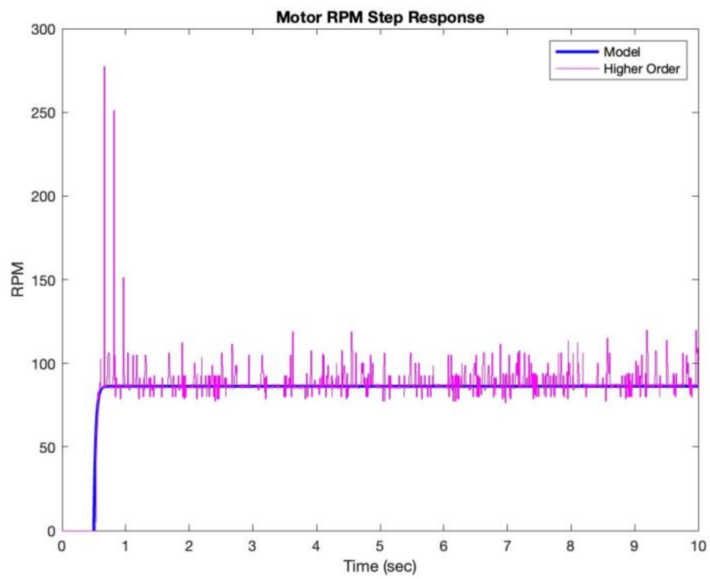
ii.

b. What are the pros and con of a filter.
    i. The pros of a filter are the control over the low and high frequency boundaries and noise removal. It is also customizable to suit one's needs. The cons are that it increases the complexity and there's a risk of over-smoothing. There is also a chance of losing information.

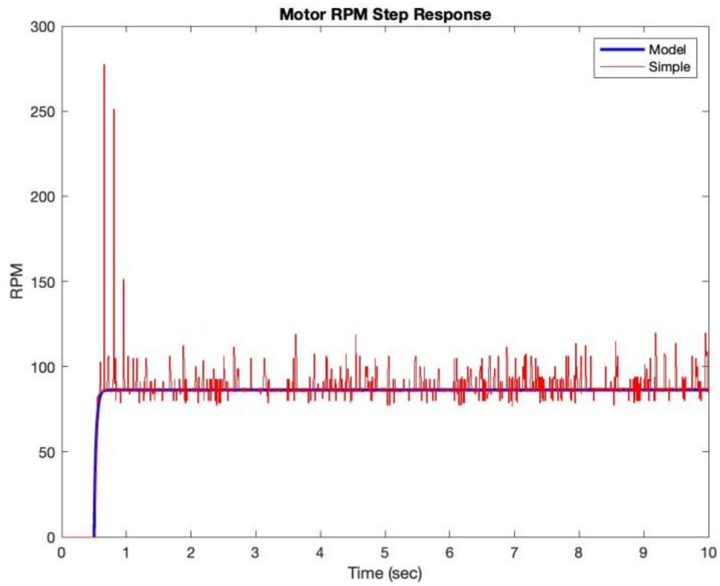
5. Creating a model.
    a. Use the same first order method as in Lab 1. Include your transfer function.

Steady: 86.25 RPM, Initial: 0 RPM
Gain = K = Steady - Initial
Gain = 86.25 - 0 = 86.25 RPM
For 63 percent, the equation is .63(K) + min
.63*(86.25) + 0 = 54.3375 RPM
On the graph, 54.3375 RPM occurs at 0.53 seconds.
Since I put a delay of 0.5 seconds, $\tau = 0.03$ seconds
$\tau = 0.03$ seconds
To = 0 RPM
K = 86.25 RPM
The transfer function is P(s) = $\frac{Y(s)}{U(s)} = \frac{K}{\tau s+1}$
For this model, P(s) = $\frac{Y(s)}{U(s)} = \frac{86.25}{0.3s+1}$

i.

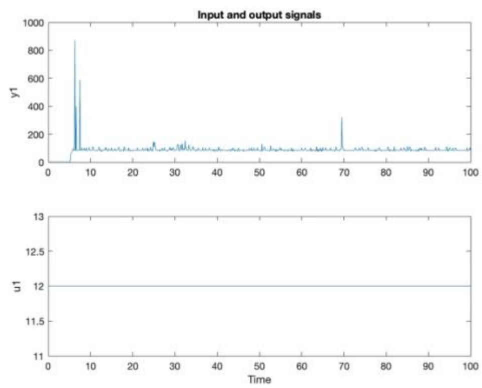


ii.

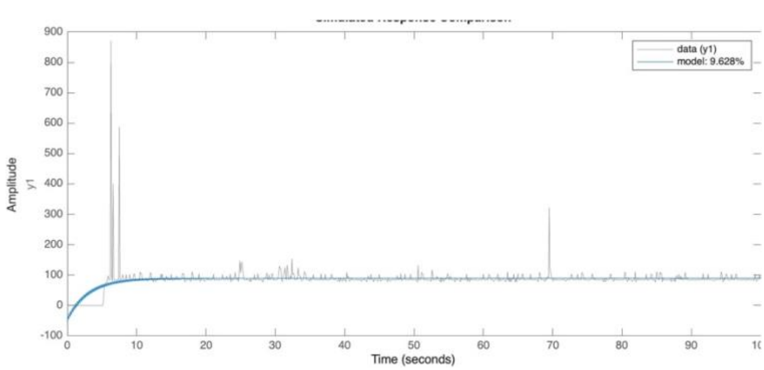


iii.

b. Use the system identification method shown in-class.



i.



ii.

iii.

```
  From input "u1" to output "y1":
          0.4832 z^-1
  -----------------------------
  1 + 0.02539 z^-1 - 0.9605 z^-2

Name: tf1
Sample time: 0.1 seconds
Discrete-time identified transfer function.

Parameterization:
   Number of poles: 2   Number of zeros: 1
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6. Understanding parameters
   a. Brainstorm tests that will allow us to calculate the terms used in equation 1 (https://ctms.engin.umich.edu/CTMS/index.php?aux=Activities_DCmotorA).
      i. For J, apply a known torque (Tm) to the motor and measure the resulting angular acceleration (a) with equation J = Tm/a
      ii. For b, measure the response of the motor to a step input voltage and observe how the motor settles to its steady-state speed. Analyze the transient response and look at settling time and overshoot
      iii. L – apply a step input voltage to the motor and measure the current response over time. L = tau*R
      iv. R – measure the resistance of the motor windings directly using a multimeter. R = V/I
      v. K – measure the torque with known current, K=Tm/I

In the next lab we will implement that PID controller, keep it ready!