ME 360: FUNDAMENTALS OF SIGNAL PROCESSING, INSTRUMENTATION, AND CONTROL

Experiment No. 4
Modeling and Identification of an Electric Motor using Step Response Methods

Pre-lab Questions

These short answer questions must be completed and turned in at the beginning of the laboratory period.

1. a. Using the following data in a MATLAB script, plot the expected step response of the motor-generator system. (5 pts)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steady state gain ( K )</td>
<td>1.2</td>
</tr>
<tr>
<td>Time constant ( \tau )</td>
<td>50 ms</td>
</tr>
<tr>
<td>Initial output voltage ( V_o )</td>
<td>0 V</td>
</tr>
<tr>
<td>Final input voltage ( V_{in}(\infty) )</td>
<td>4 V</td>
</tr>
<tr>
<td>Starting time ( t_0 )</td>
<td>0 s</td>
</tr>
<tr>
<td>Ending time ( t_f )</td>
<td>0.5 s</td>
</tr>
</tbody>
</table>

   b. On the step response plot from above, draw a tangent line at \( t = 0 \), and determine the intersection of this line with the long-time asymptote. (5 pts)

   c. Using the step response plot from above, determine the time at which the voltage change reaches 63.2% of its maximum value. Mark this point on the plot. (5 pts)

   d. Explain mathematically why \( \tau \) is found at this 63.2% point. (5 pts)

2. See Appendix C Method 3. Show that (6 pts)

   \[
   \tau = \int_0^\infty \left[ 1 - \frac{V_{out}(t)}{V_{out}(\infty)} \right] dt
   \]

   with our first order system that has the equation

   \[
   V_{out}(t) = V_{out}(\infty) \left[ 1 - \exp \left( -t / \tau \right) \right]
   \]

3. Variation in \( K \) as a function of input voltage demonstrates what about our model? (2 pts)

4. List the four methods used to calculate \( \tau \) in this lab. (2 pts)