EE 342 - Section - 3

Fall 2013

Instructor's Name: #############

Experiment # 1 - System Modeling

January 14, 2014

**PURPOSE**
The purpose of this lab is to create a control system representation for the MCSL system by looking at the effect of changing the RPM of the system and making measurements.

**CIRCUIT FIGURES**

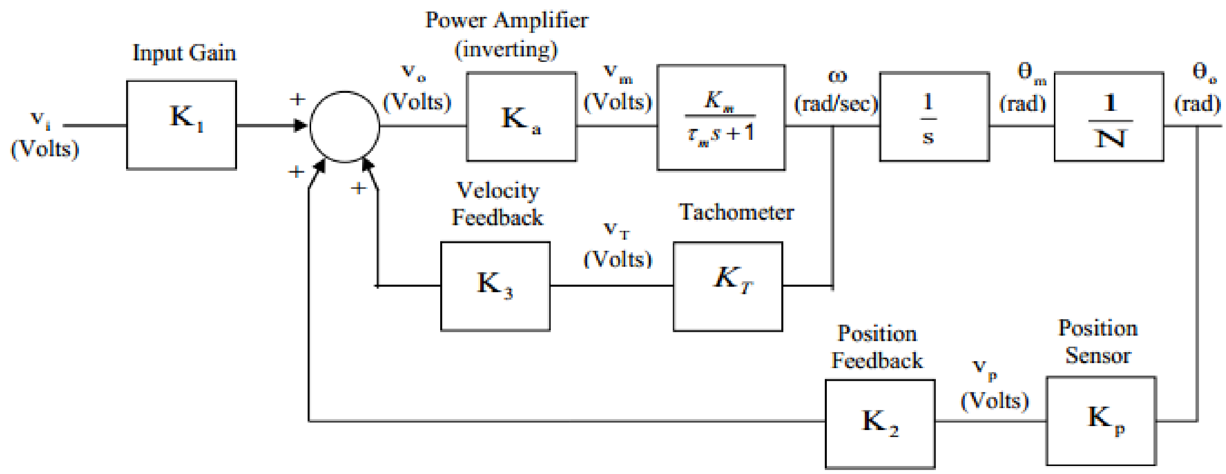


**Figure 1: Block Diagram for MCSL**

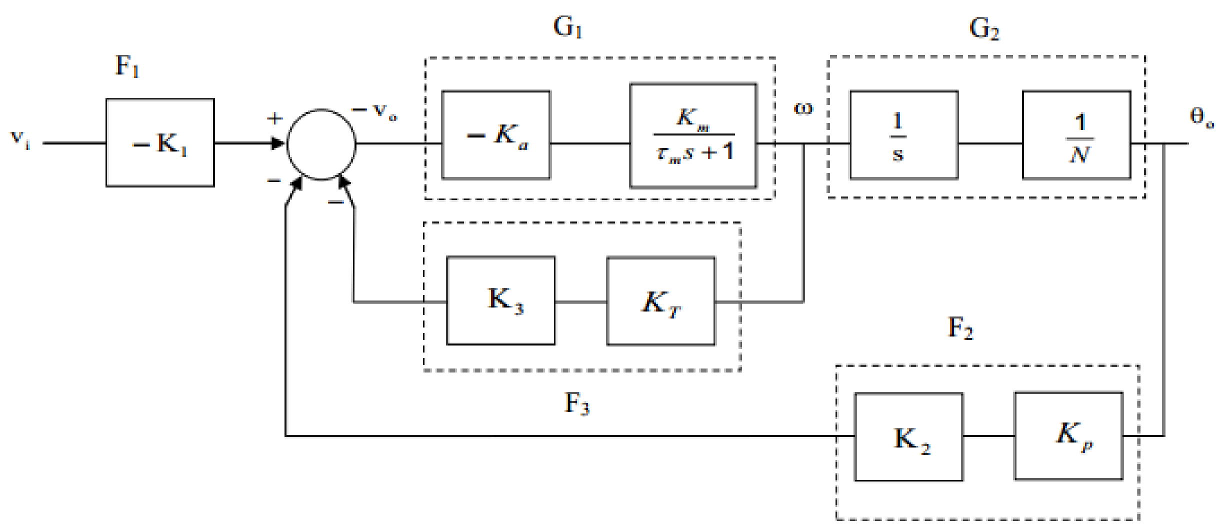


**Figure 2: Block Diagram for Closed-Loop System**

**PROCEDURE**

1. Connect the leads of the MCSL to the control console. Make sure the speed reducer is not attached to the potentiometer. Connect the summing node output to the op-amp's input and the op-amp's output to the power amp's input. Between the op-amp's input and output, connect a 30kOhm resistor.

2. Flip the step input switch to + , adjusting $v_i$ to obtain the desired RPM and measurements as shown in the table in figure 3. Then create the plots as shown in figures 5, 6, and 7. The slopes for these figures are $K_T$, $K_m$, and $K_a$, respectively.

3. Using the oscilloscope, measure $\tau_m$ by applying a step voltage to the system and measure how long it takes for $\omega$ to respond.

4. Attach the speed reducer, flipping the feedback switch to -. Create a plot as shown in figure 11, measuring the slope to obtain $K_p$.

5. Determine N by taking the ratio of the number of rotations of the input shaft to the corresponding rotations caused in the output shaft.

6. Find the transfer function H(s), leaving $K_1$, $K_2$, and $K_3$ as unknown variables.

7. Create a table of the parameters for the system used in this lab, as shown in figure 4.

**TABLES AND GRAPHS**

| RPM | Radians/Sec | Va(V) | Vm(V) | Vt(V) |
|---|---|---|---|---|
| 0 | 0 | -.0044 | .021 | 0 |
| 500 | 52.359 | -.658 | 3.33 | -7.46 |
| 1000 | 104.719 | -1.17 | 6.3 | -16.2 |
| 1500 | 157.08 | -1.58 | 8.53 | -23.5 |
| 2000 | 209.439 | -2.03 | 11.15 | -31.8 |
| 2500 | 261.8 | -2.4 | 13.15 | -38.3 |

**Figure 3: Measurements for Open-Loop test**

| Parameter | Value |
|---|---|
| $K_m$ (radians/volt-sec) | 18.48 |
| $K_a$ (Volts/Volt) | -4.9 |
| $\tau_m$ (s) | 0.172 |
| N (radians/radian) | 8.75 |
| $K_p$ (Volts/radian) | 20.61 |
| $K_T$ (Volt-sec/radian) | -0.146 |

**Figure 4: Parameters for MCSL System**

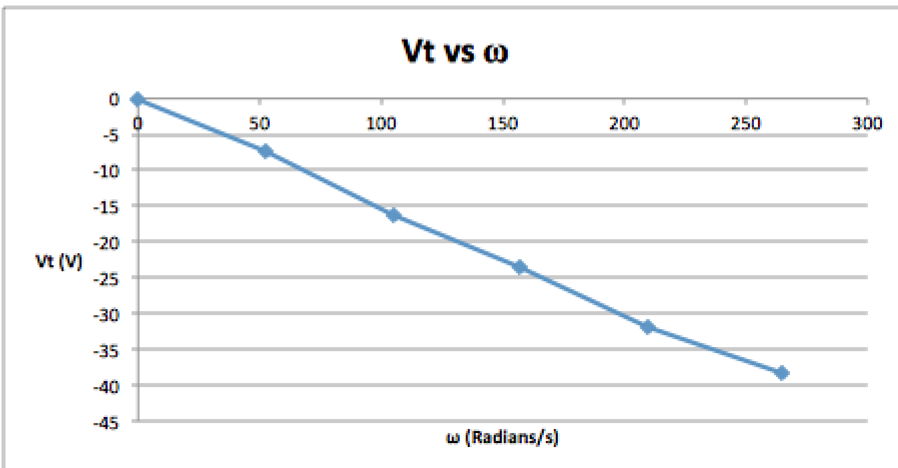


**Figure 5: $V_t$ vs. ω**

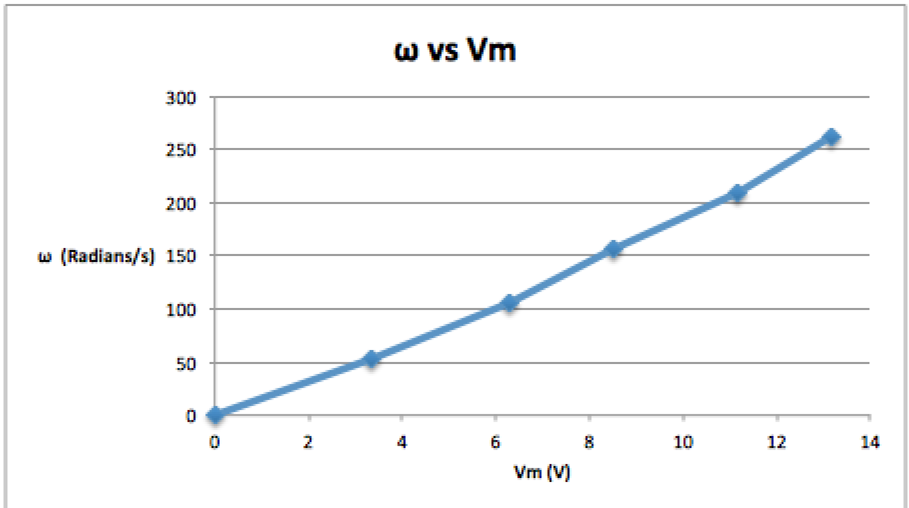


**Figure 6: ω vs. $V_m$**

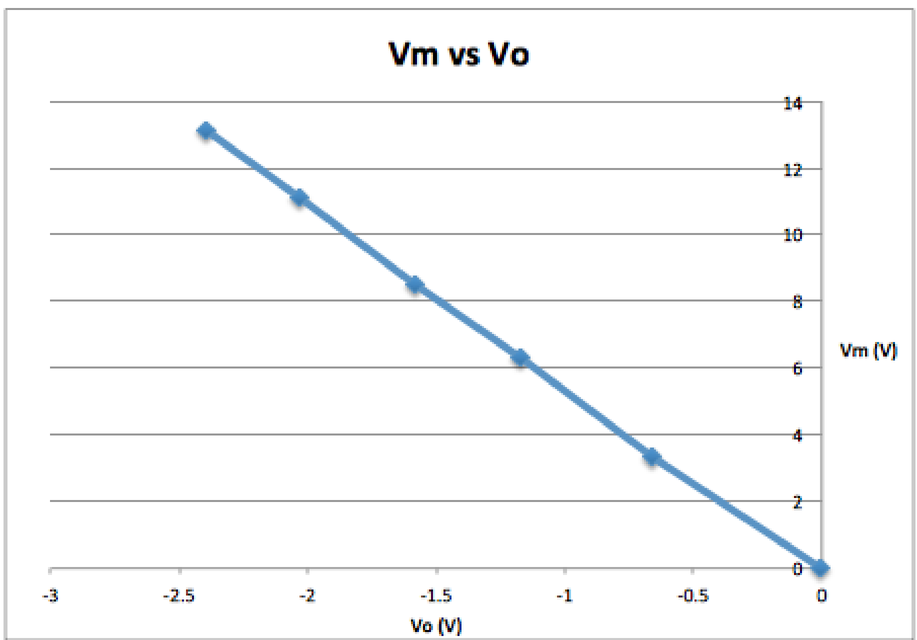


**Figure 7: $V_m$ vs. $V_o$**

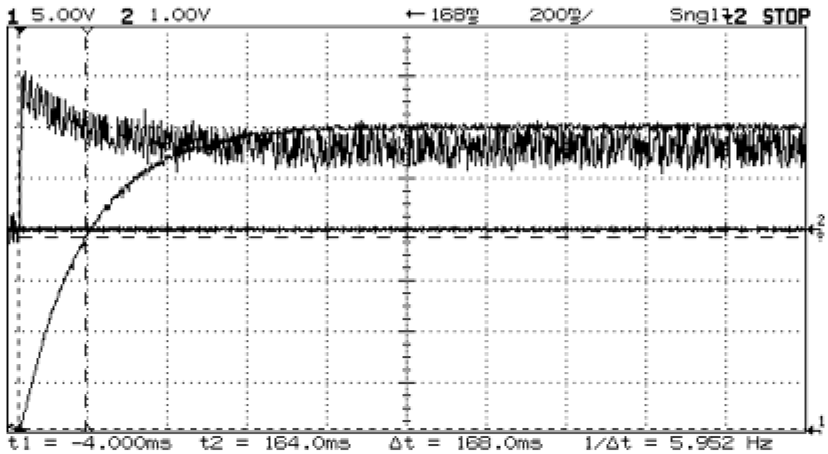


**Figure 8: Step response at 2000 RPM**

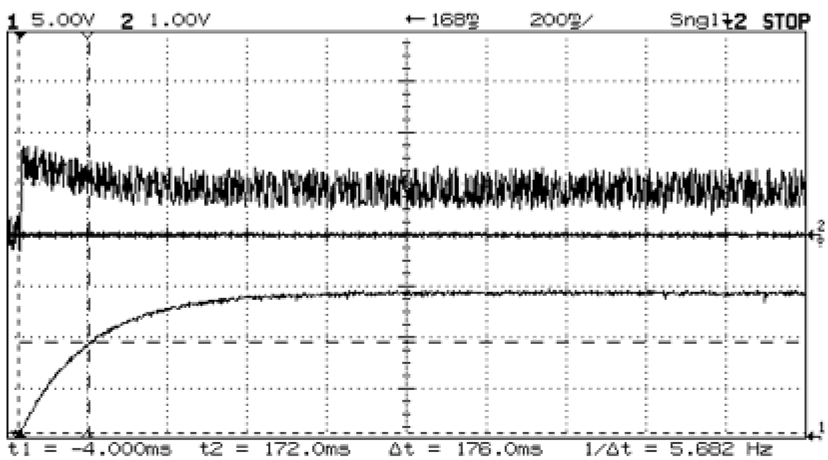


**Figure 9: Step response at 1000 RPM**

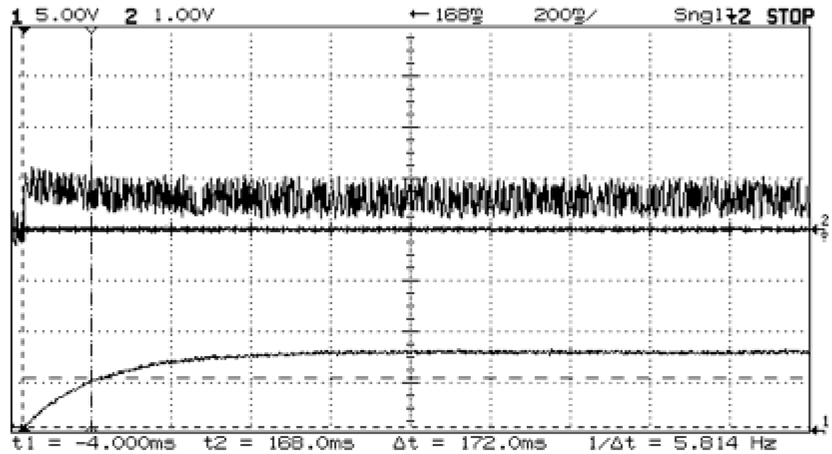


**Figure 10: Step response at 500 RPM**

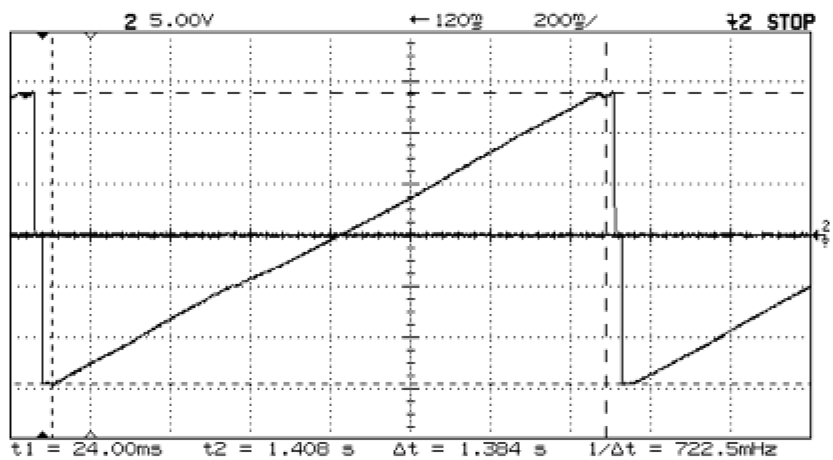


**Figure 11: Plot to obtain $K_{P\backslash}$**

Deadzone = 4.90 radians

**SAMPLE CALCULATIONS**

$K_P$ = 28.44volts / 1.38 radians = 20.61 Volts/radian.

$\tau_m = \tau_2 - \tau_1$ = 168 ms - (-4 ms) = 172 ms.

N = 17.5/2 = 8.75

**DISCUSSION**

This lab went fairly smoothly. Our data generally followed our expectations. After making graphs of the data from the open-loop tests, it was clear that most of the variations as the RPM was increased were a positive or negative linear change. Our differing K values were also easy to obtain from these plots.

$K_P$, measured after attaching the speed reducer, seemed to come out fine. There is no real comparison to make against other data, but based on the fact that our other data and experimenting had gone as expected, it in unlikely that any great error could have occurred in this step. To find N, we spun the flywheel 17.5 times to turn the shaft twice. This resulted in our N values of 8.75, which was very close to the theoretical value of 9.

**CONCLUSIONS**

**(Student 1):** The purpose of the lab seemed unclear at first when doing the open loop tests, however, after attaching the speed reducer, it became a lot more clear what our results were trying to accomplish. It was nice to be able to physically see and measure a $\tau_m$ by viewing the response curve and the timing it took for the motor to respond.

**(Student 2):** In this lab, we found constant values for the transfer function of the MCSL. Our values obtained were around as expected as we took data from the oscilloscope and measurements from the digital multimeter. By taking the slope of the graphs we plotted we were able to find the different “k” values. Our graphs came out as expected and we were able to find the slope easily.

**(Student 3):** This lab first accomplishes solving for the values of the constants that are present in the transfer function of the MCSL. An accurate value of these values was able to be obtained by taking multiple data points of voltages and a slope of the data was used to find that constant. Additionally the time constant was found by looking at the step response of the MCSL on the oscilloscope. The time constant could be found by using cursors to find when the step response has reached 63 percent of its maximum value.