<u>SRV02 SPEED CONTROL: Lab 7 Report</u>

Course: ENG 4550

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Table Of Contents

Procedure:

Step Response with LEAD Control (Simulation)

The purpose of the simulation is to confirm that the desired response specifications using the LEAD control are met. The steady state response with LEAD control was found during simulation, and its characteristics (steady-state error, time step, and percent overshoot) were found. A square, motor speed reference was created, ranging from 2.5 to 7.5 rad/s, and was compared to the simulation signal. The steady-state error can be found by calculating the difference between the setpoint and the simulation which were shown in Figure 2.

$$y_{max} = \text{max - initial value} \tag{1.1}$$

$$R_0 = y_{ss} - \text{initial value} \tag{1.2}$$

To calculate the percentage overshoot, the difference between y_{max} and R_0 is divided by R_0 and the result is multiplied by 100%.

$$PO = \frac{100(ymax - R0)}{R0}\% \tag{1.3}$$

Step Response with LEAD Control (Implementation)

The purpose of implementation is to verify that the motor is not saturated and to find the effect of the setpoint weight. A square, motor speed reference was created, ranging from 2.5 to 7.5 rad/s. The steady state response with LEAD controller was found during simulation, and its characteristics (steady-state error, time step, and percent overshoot) were found. A square, motor speed reference was created, ranging from 2.5 to 7.5 rad/s, and compared to the experimental signal. The steady-state error can be found by calculating the difference between the setpoint and the simulation which were shown in Figure 4.

Results:

Step Response with LEAD Control (Simulation)

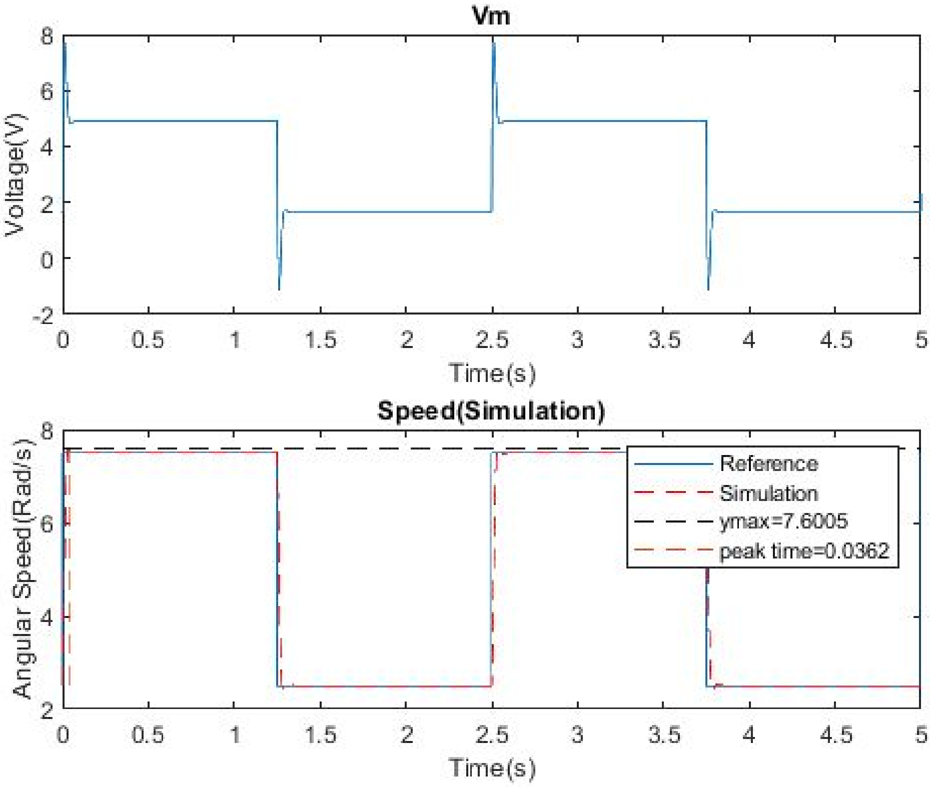

Figure 1: Plot of simulated step response with LEAD Control. Shown is the voltage, as well as the Reference and Simulated Speeds of the Motor.

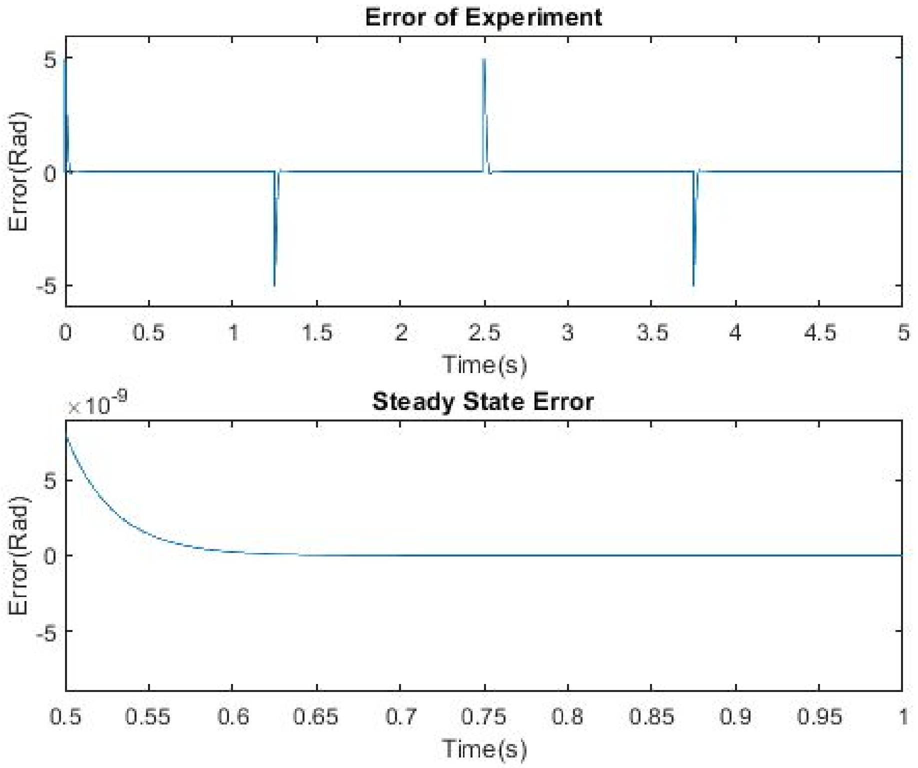

Figure 2: Plot of simulated error with LEAD Control. Shown is the error, as well as the Steady State Error. Note that the steady state error decreases to 0 as time elapses.

Step Response with LEAD Control (Implementation)

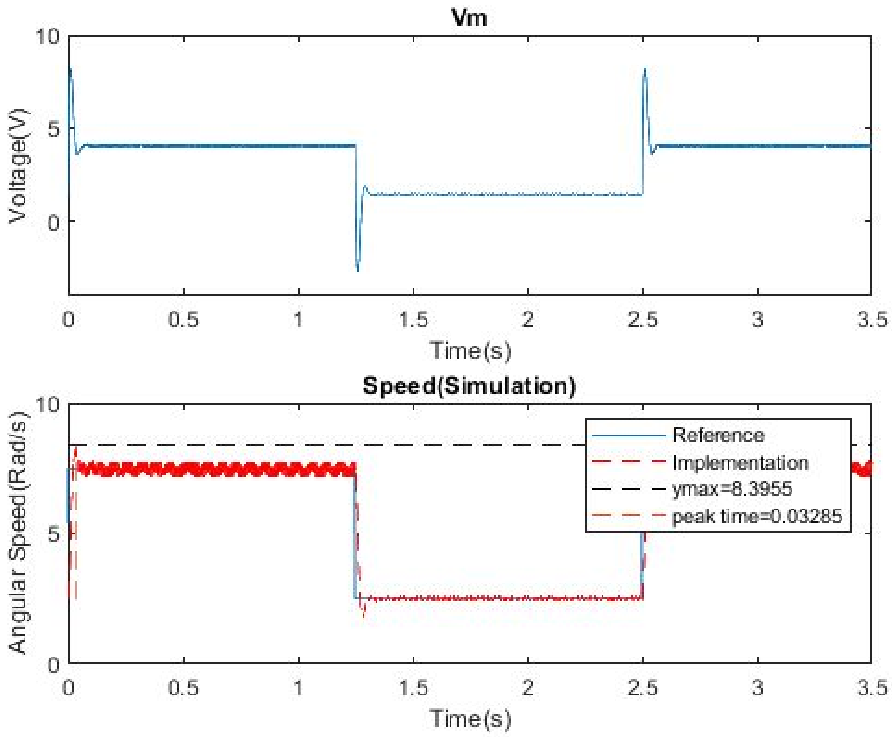

Figure 3: Plot of simulated step response with LEAD Control. Shown is the voltage, as well as the Reference and Implemented Speeds of the Motor.

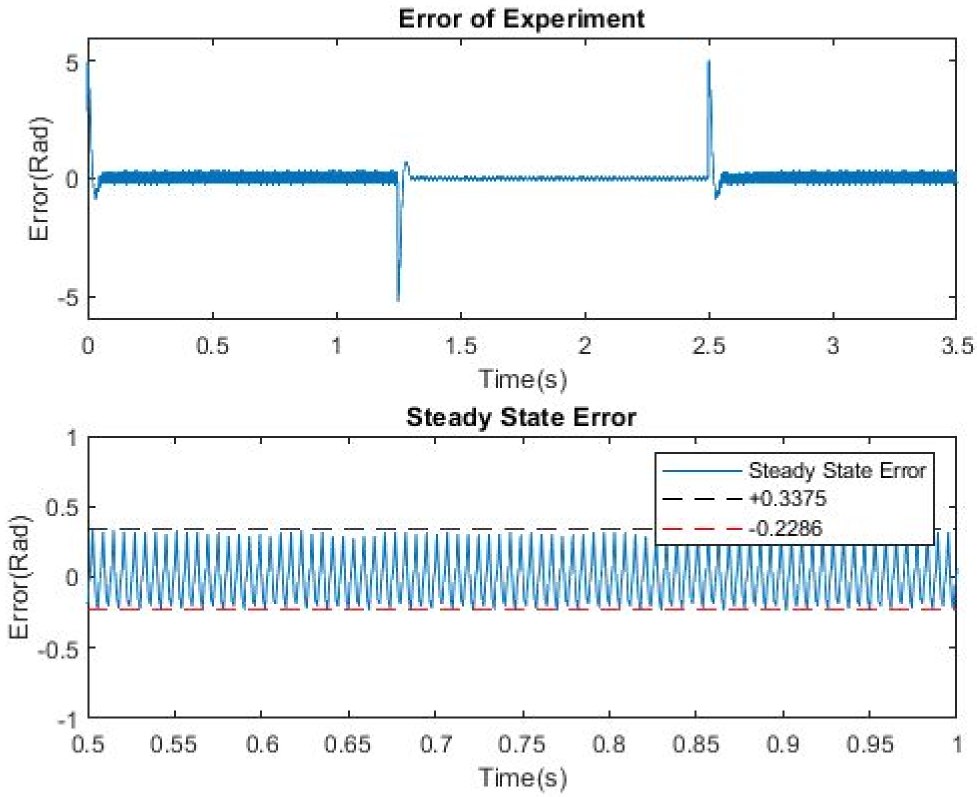

Figure 4: Plot of implemented error with PI Control. Shown is the error, as well as the Steady State Error (at 7.5 rad/s). The steady state error was calculated from 0.5 to 1 s, when the motor has 7.5 rad/s speed.

Section /Question	**Description**	**Symbol**	**Value**	**Unit**
Question 4	**Pre-Lab: DC Gain Estimate** DC Gain Estimate of Pi(s)	|Pi(1)|	1.53	
Question 5	**Pre-Lab: Gain Crossover Frequency** Gain crossover frequency	wg	1.524	rad/s
Section 3.3.2.1	**In-Lab: Step Response Simulation with Lead Control** Peak time Percent overshoot Steady-state error	tp PO ess	0.0362 2.01 0	s % rad/s
Section 3.3.2.2	**In-Lab: Lead Speed Control Implementation** Peak time Percentage overshoot Steady-state error	tp PO ess	0.0328 12.66 0.75	s % rad/s

Table 1: Properties of the PV controller.

Analysis:

Step Response with LEAD Control (Simulation)

Using Figure 2,

ess=0 rad/s

Using Figure 1,

$$y_{max} = \text{max - initial value} = 7.6005 - 2.5 = 5.1005$$

$$R_0 = y_{ss} - \text{initial value} = 7.5 - 2.5 = 5$$

$$\textbf{PO=}\ \frac{100(ymax - R0)}{R0}\% = \textbf{2.01\%}$$

Using FIgure 1, peak time was found:

tp=0.0362s

Step Response with LEAD Control (Implementation)

With Noise

Using Figure 4,

ess= =+0.3375/-0.2286 rad/s

Using Figure 3,

$$y_{max} = \text{max - initial value} = 8.3955 - 2.5 = 5.8955$$

$$R_0 = y_{ss} - \text{initial value} = 7.5 - 2.5 = 5$$

$$\textbf{PO=}\ \frac{100(ymax - R0)}{R0}\% = \textbf{17.91\%}$$

Using Figure 3, peak time was found:

tp=0.03285s

Without Noise

Knowing that the noise causes the signal to oscillate between +/- 0.2625 rad/s, the error was modified to take this into account.

Using Figure 4,

ess= +0.75 rad/s

Using Figure 3, and knowing that the noise causes the signal to oscillate between +/- 0.2625 rad/s, the PO was modified to take this into account.

$$y_{max} = \text{max - initial value} = (8.3955-0.2625)-2.5=5.633$$

$$R_0 = y_{ss} - \text{initial value} = 7.5-2.5=5$$

$$\textbf{PO=} \frac{100(ymax-R0)}{R0}\% = 12.66\,\%$$

Using Figure 3, peak time was found:

tp=0.03285s

Conclusion:

Step Response with LEAD Control (Simulation)

All three requirements are met; the steady state error was found to be 0(ess requirement was 0), and the peak time,tp, was equal to 0.0362s (less than 0.05 requirement). The Percent Overshoot is 2.01% (below the the 5% requirement).

Step Response with LEAD Control (Implementation)

One of the measured values (with noise taken into account) met the requirements; the peak time,tp, was less than 0.05s. The Percent Overshoot was found to be 12.66%, and ess was not 0; does not meet the requirements. The noise was not sufficiently removed. There might be noise from the voltage supply to the motor, causing the voltage to deviate, therefore causing the speed to deviate. There might be noise due to back-emf from the motor might be underestimated when switching from 2.5 to 7.5 rad/s (before the controller can control it).

References

Apkarian, J., Lévis, M., & Gurocak, H. (Eds.). (n.d.). SRV02 Base Unit Experiment For Matlab/ Simulink. Retrieved October 20, 2018.