SRV02 SPEED CONTROL: Lab 6 Report

Course: ENG 4550

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Lab#: 6

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Procedure:

Step Response with PI Control (Simulation)

The purpose of the simulation is to confirm that the desired response specifications in an ideal condition are satisfied. The steady state response with PI 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 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.

To calculate the y_{max} value the maximum value is subtracted by the initial value.

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

To calculate the R_0 value the steady state value is subtracted by the initial value.

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

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 PI 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 PI 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 PI Control (Simulation)

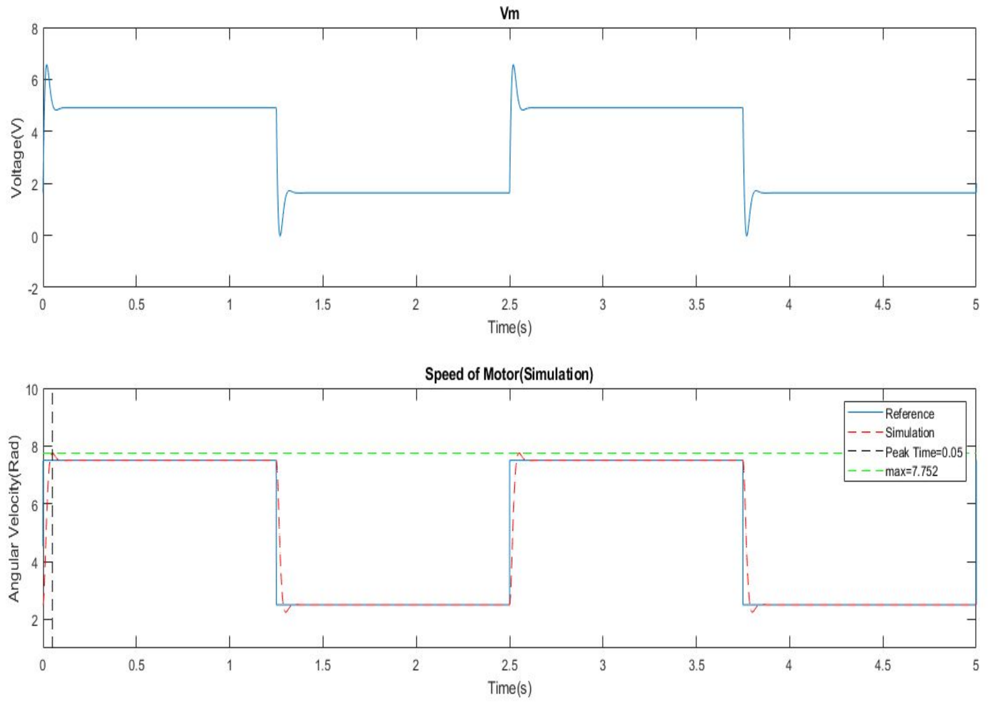

Figure 1: Plot of simulated step response with PI Control. Shown is the voltage, as well as the Reference and Simulated Speeds of the Motor.

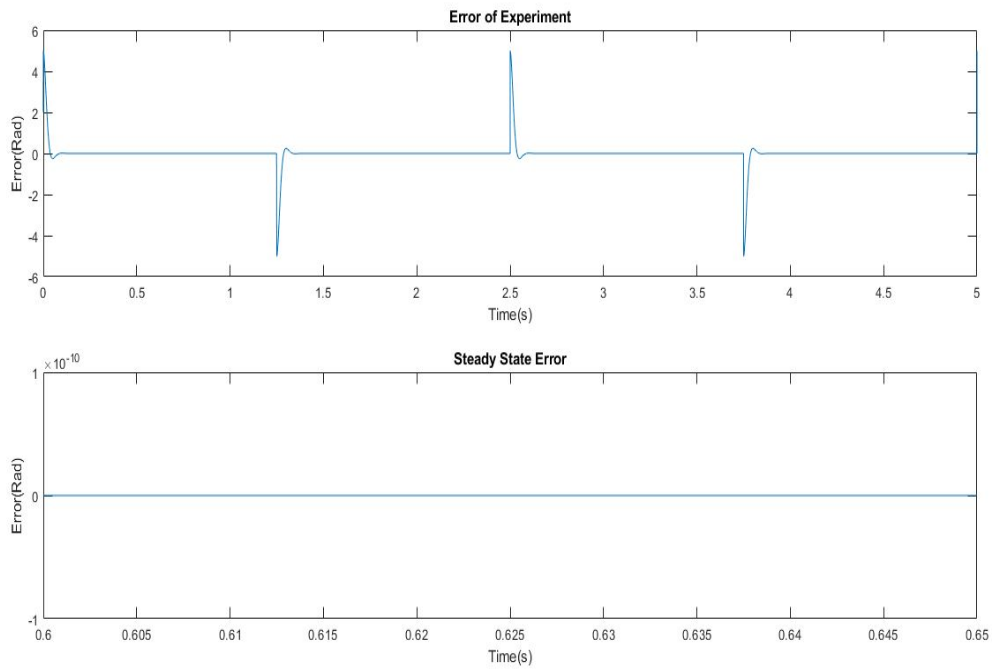

Figure 2: Plot of simulated error with PI Control. Shown is the error, as well as the Steady State Error.

Step Response with PI Control (Implementation)

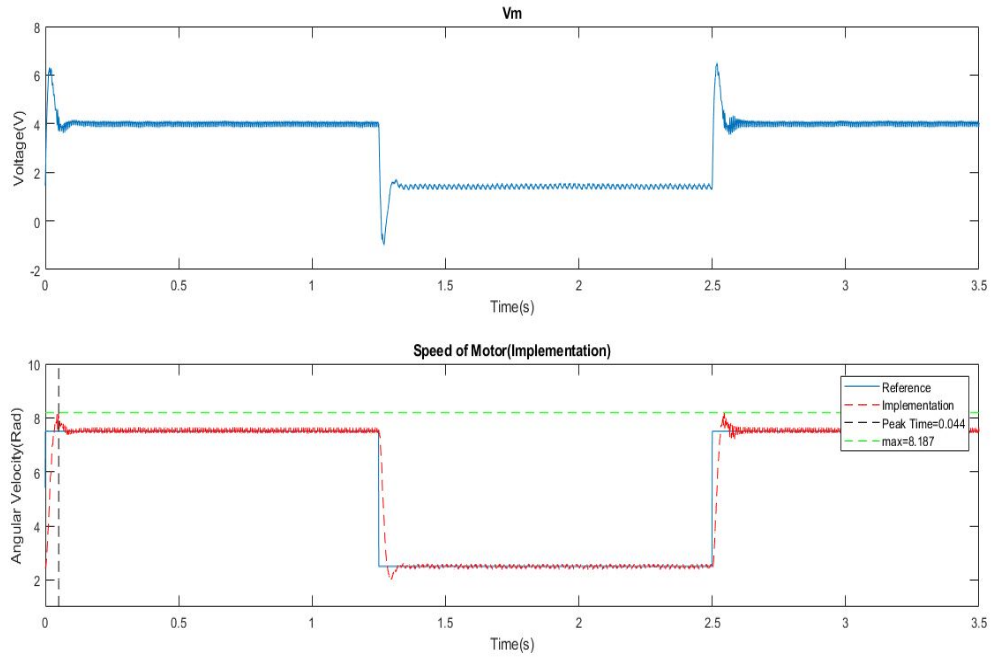

Figure 3: Plot of simulated step response with PI Control. Shown is the voltage, as well as the Reference and Implemented Speeds of the Motor.

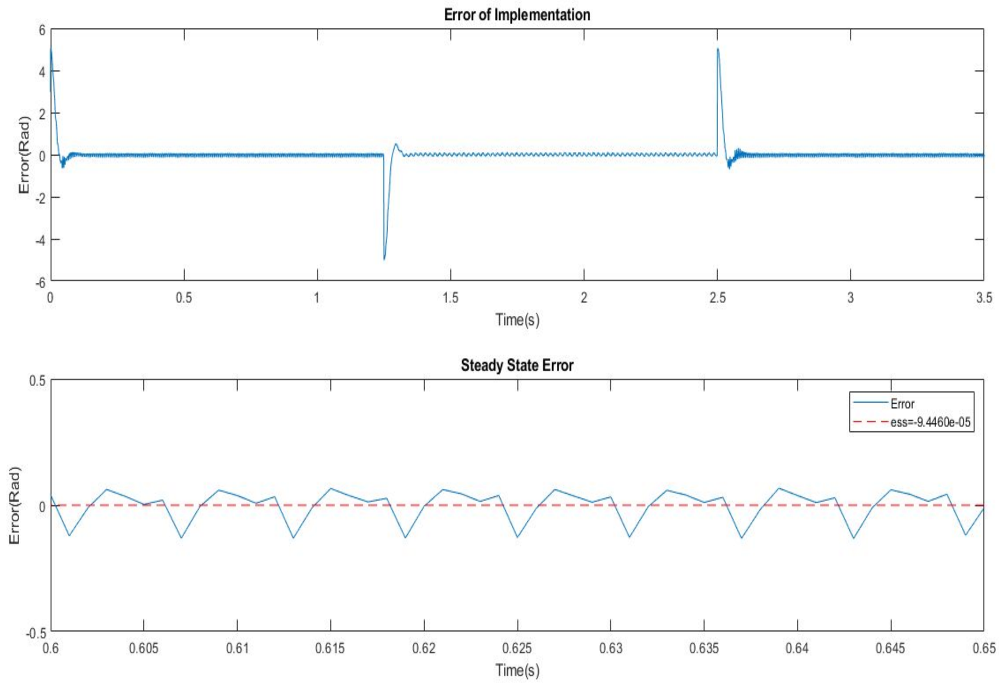

Figure 4: Plot of implemented error with PI Control. Shown is the error, as well as the Steady State Error (at 7.5 rad/s). The steady state error was calculated from 0.6 to 0.65 s, when the motor has 7.5 rad/s speed.

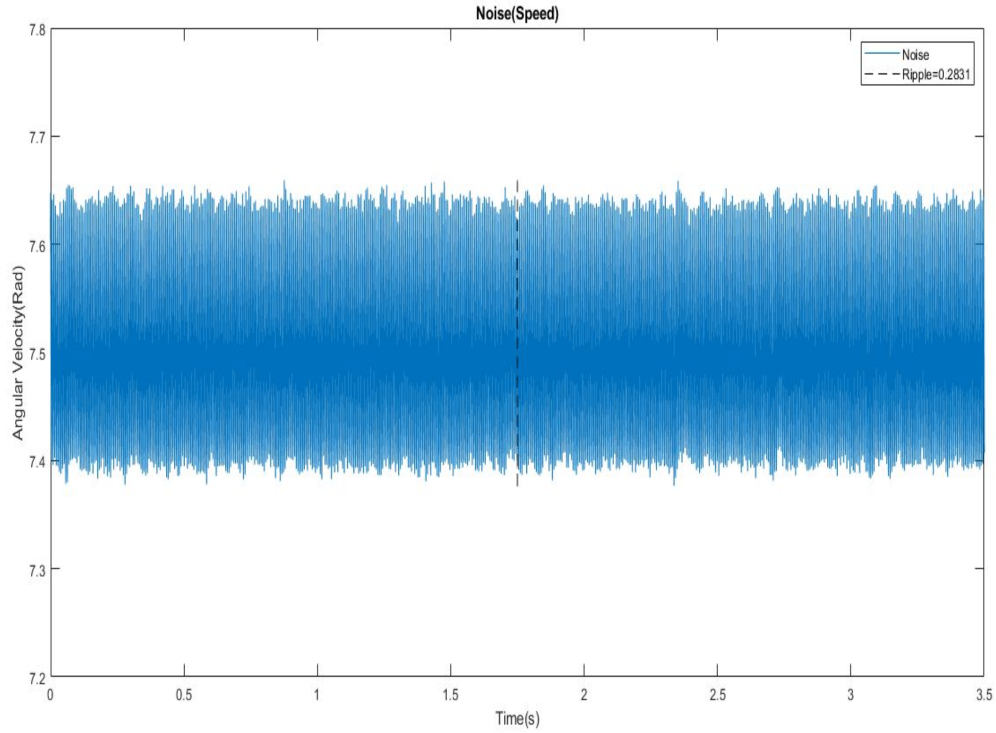

Figure 5: Plot of noise at 7.5 rad/s. Peak-to-Peak ripple is 0.2831 when speed is 7.5 rad/s.

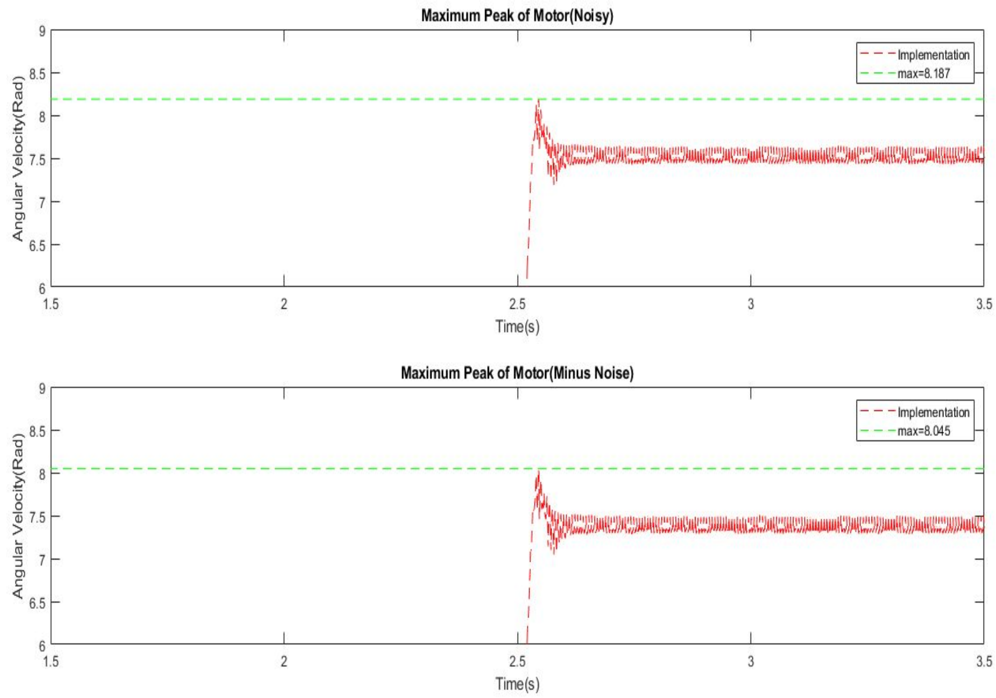

Figure 6: Step response of controller with and w/o noise. Step response without noise obtained by subtracting ripple/2 from step response with noise.

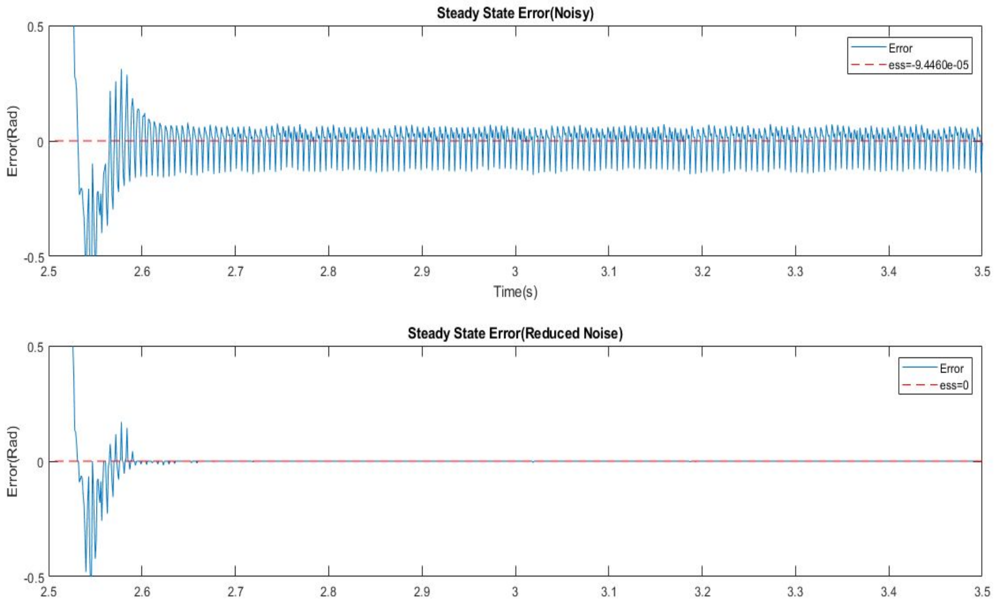

Figure 7: Error with with and without noise.

Section /Question	**Description**	**Symbol**	**Value**	**Unit**
Question 2	**Pre-Lab: PI Gains** Proportional Gain Integral Gain Open-Loop Time Constant Open-Loop Steady-state Gain	kp ki tau K	1.33 125 0.0254 1.53	V*s/rad rad/V s rad/s/v
Section 3.3.1.1	**In-Lab: PI Step Response Simulation** Peak time Percent overshoot Steady-state error	tp PO ess	0.05 5.04% 0	s % rad/s
Section 3.3.1.2	**In-Lab: PI Speed Control Implementation** Measured peak-to-peak ripple Steady-state error Peak time Percent overshoot	eω,meas ess tp PO	0.2831 0 0.044 10.9	rad/s rad/s s %

Table 1: Properties of the PV controller.

Analysis:

Step Response with PI Control (Simulation)

Using Figure 2,

$$\mathbf{e_{ss}=0\ rad/s}$$

Using Figure 1,

$$y_{max} = \text{max - initial value} = 7.752 - 2.5 = 5.252$$

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

$$\mathbf{PO=} \frac{100(ymax - R0)}{R0}\% = \mathbf{5.04\%}$$

Using FIgure 1, peak time was found:

$$\mathbf{t_p=0.05s}$$

Step Response with PI Control (Implementation)

With Noise

Using Figure 7,

$$\mathbf{e_{ss}=9.4 *10^{-5}\ rad/s}$$

Using Figure 6,

$$y_{max} = \text{max - initial value} = 8.187 - 2.5 = 5.687$$

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

$$\mathbf{PO=} \frac{100(ymax - R0)}{R0}\% = \mathbf{13.74\%}$$

Using Figure 3, peak time was found:

$$\mathbf{t_p=0.044s}$$

Noise

The theoretical error is 0.525 rad/s; the theoretical error is almost double the experimental error (0.2831).

Knowing that the error might raise or lower the actual value of the step response by +/- 0.14155, the AWGN(Additive White Gaussian Noise) can be partially eliminated (shown in Figure 6 and Figure 7).

No Noise

Using Figure 7,

$$\mathbf{e_{ss}=0\ rad/s}$$

Using Figure 6,

$$y_{max} = \text{max - initial value} = 8.045 - 2.5 = 5.545$$

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

$$\mathbf{PO=} \frac{100(ymax - R0)}{R0}\% = \mathbf{10.09\%}$$

Using Figure 3, peak time was found to be:

$$t_p = 0.044s$$

Conclusion:

Step Response with PI Control (Simulation)

Two of the measured values meet the requirements; the steady state error was found to be 0(e_{ss} requirement was 0), and the peak time,t_p, was equal to 0.05s. The Percent Overshoot is slightly above the 5% requirement, the integral gain could have been slightly changed to yield the 5% overshoot.

Step Response with PI Control (Implementation)

Two of the measured values (with noise taken into account) met the requirements; the steady state error was found to be 0(e_{ss} requirement was 0), and the peak time,tp, was less than 0.05s. The Percent Overshoot was found to be 10.9%; is above the 5% requirement. 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 angular speed to deviate.

References

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