<u>SRV02 POSITION CONTROL: Lab 5 Report</u>

Course: ENG 4550

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Lab#: 5

Date: November 14, 2018

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Procedure:

Hypothesis

If integral control is added to the controller, then the steady state error will significantly decrease (ideally zero), because the integrator will take the accumulated error and increase the voltage to decrease the steady-state error.

$$V_m(t)=k_p(\theta_d(d)-\theta_l(t)) + k_i\int(\theta d(d)-\theta l(t))dt - k_v(\tfrac{d}{dt}\theta_l(t)) \quad (1)$$

The independent variable is $\theta_l(t)$ and $\theta_d(d)$. The dependent variable is $V_m(t)$.

Simulated Controller With Ramp Input

The goal of this lab was to verify that the system with the PV controller can meet the zero state error without saturating the motor and to decrease the steady-state error of the simulated ramp response through simulation. This was done by generating a triangle reference signal and comparing it to the ramp-response. The PIV controller was meant to decrease the error between the reference and the output. The steady-state error(e_{ss}) was found by looking at the difference between the setpoint and the simulation and finding the error value at steady state using eq.2. for a time t.

$$e_{ss}(t)=r_{ss}(t)-y_{ss}(t) \quad (2)$$

where $r_{ss}(t)$ is the value of the steady-state input and $y_{ss}(t)$ is the steady-state value of the output.

The theoretical integral gain, k_i, can be found using eq.2.

$$k_i=\frac{V_m-k_p e_{ss}}{\int_o^{ti} e_{ss}dt} = 38.965 \quad (3)$$

Implemented Controller With Ramp Input

The goal of this lab was to determine how well the system can track a ramp position input and to decrease the steady-state error of the experimental ramp using the SRV02 motor. This was done by generating a triangle reference signal and comparing it to the ramp-response. The PIV controller was meant to decrease the error between the reference and the output. The steady-state error was found by looking at the difference between the setpoint and the simulation and finding the error value at steady state. The theoretical integral gain, k_i, can be found using eq.3.

Results:

Simulated Controller With Ramp Input

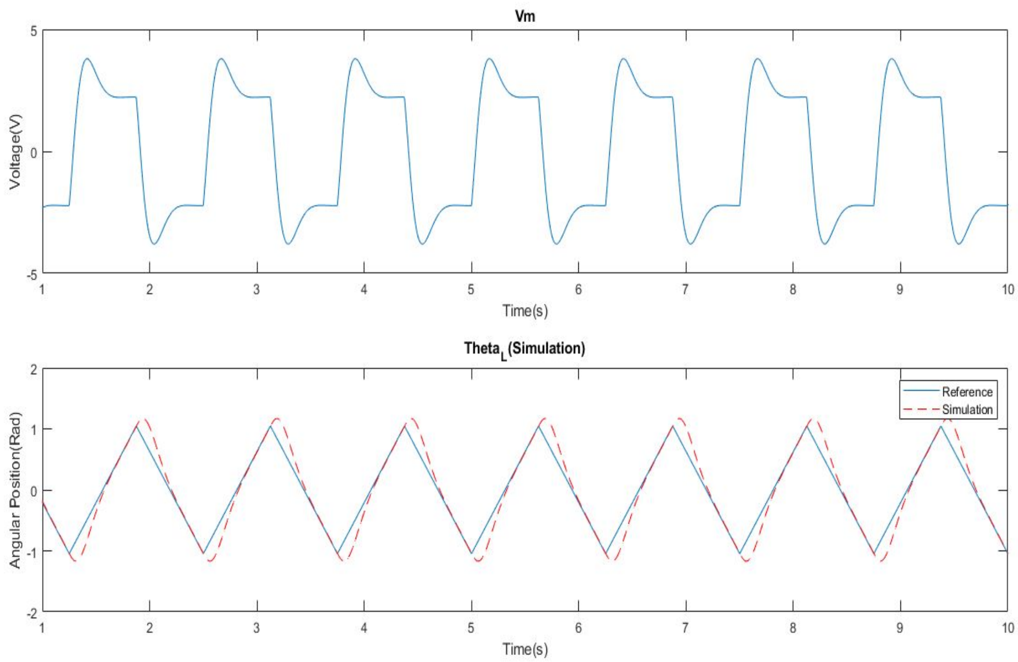

Figure 1: The ramp response (simulation) of the SRV02; plotted is the Vm (input) and the reference and simulated positions (output) controller with PIV controller.

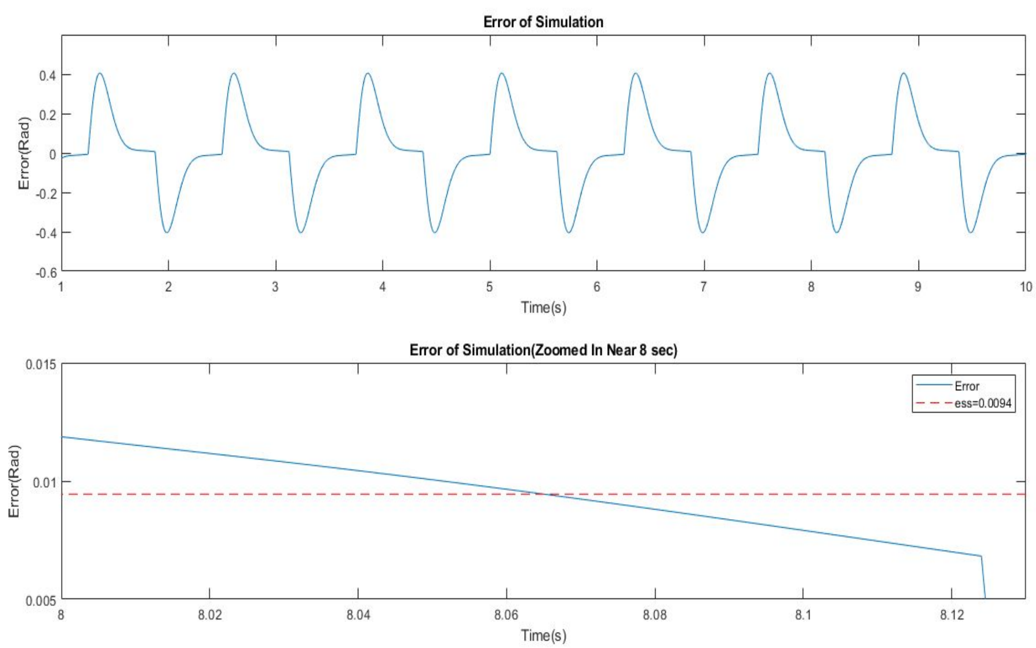

Figure 2: The ramp response error (simulation) of the SRV02 controlled with PIV controller. Steady state error is considered when the response has settled. The average was taken from the end portion to get the steady state error.

Implemented Controller With Ramp Input

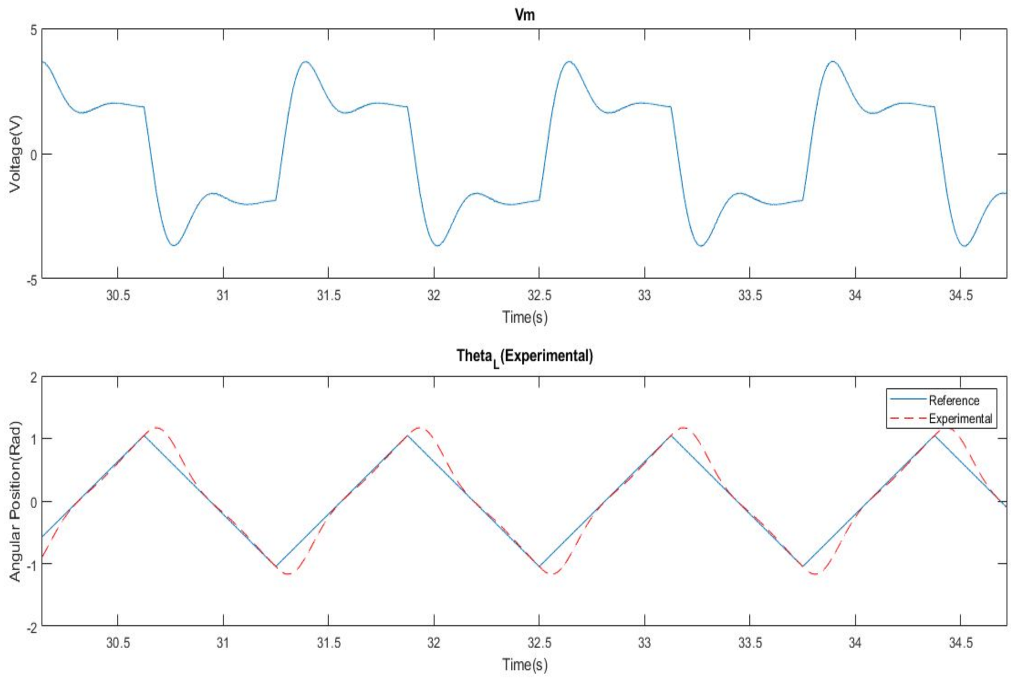

Figure 3: The ramp response (experimental) of the SRV02; plotted is the Vm (input) and the reference position and experimental position (output).

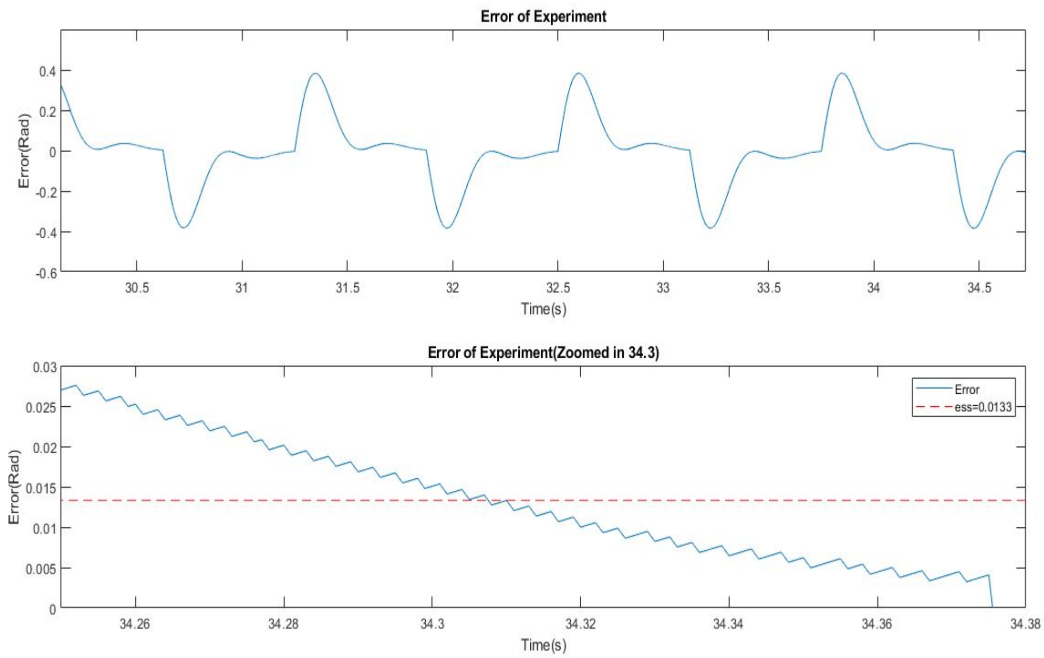

Figure 4: The ramp response error (experimental) of the SRV02. Steady state error is considered when the response has settled. The average was taken of the end portion to get the steady state error.

Section /Question	Description	Symbol	Value	Unit
Question 4	Pre-Lab: Model Parameters Open-loop Steady-state Gain Open-loop Time constant	K tau	1.53 0.0254	Rad/s/v s
Question 4	Pre-Lab: PV Gain Design Proportional gain Velocity gain	k_p k_v	7.8187 -0.1565	V/rad V*s/rad
Question 7	Pre-Lab: Integral Gain Design Integral gain	k_i	38.956	V/(s*rad)
2.3.3	Ramp Response Simulation with no steady-state error Steady-state error	e_{ss}	0.0094	rad
2.3.3	Ramp Response Implementation with no steady-state error Steady-state error	e_{ss}	0.0133	rad

Table 1: Properties of the PV controller.

Analysis:

Simulated Controller With Ramp Input

The error was found by looking at the difference between the simulation and the setpoint (Figure 2). The steady-state error is then plotted and e_{ss} was taken as the average of the error for a small amount of time at steady state.

$$e_{ss}=0.0094 \text{ rad}$$

Implemented Controller With Ramp Input

The error was found by looking at the difference between the simulation and the setpoint (Figure 4). The steady-state error is then plotted ande_{ss} was taken as the average of the error for a small amount of time at steady state.

$$e_{ss}=0.0133 \text{ rad}$$

Conclusion:

Simulated Controller With Ramp Input

The e_{ss} found in the simulation (0.0094 rad) is close to the theoretical e_{ss} value of 0 rad. The motor was not saturated in order to decrease the steady-state error; the max voltage applied to the motor was 4.3 V (Figure 1), which is much lower than the 10 V needed to saturate the motor.

Implemented Controller With Ramp Input

The e_{ss} found in the experiment (0.0133 rad) is close to the theoretical e_{ss} value of 0 rad. The motor was not saturated in order to decrease the steady-state error; the max voltage applied to the motor was 3.7 V (Figure 3), which is much lower than the 10 V needed to saturate the motor.

References

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