SRV02 POSITION CONTROL: Lab 3 Report

Course: ENG 4550

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Lab#: 3

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Procedure:

Closed-Loop Response with the PV Controller

The main goal of the simulation was to ensure that the PV controller can track the output to the reference signal, and within the requirements (PO<5%, t_p<0.2s, e_{ss}=0). This was done thru simulation in Simulink. A step reference of a square wave with step amplitude of π/4 was generated; the step response was plotted, and the characteristics (PO, t_p, e_{ss}) were found. PO was found by finding the values y_{max} and R_0 in the plots and applying equation 1.3. The y_{max} value would be equal to distance from the initial θ_L(rad) value to the max (Equation 1.1). R_0 is the distance from the initial value to y_{ss}(Equation 1.2). e_{ss} was found by looking at the plot.

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

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

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

The peak time was the difference in time from initial value(t_0) to peak time(t_{max}), as shown in equation 1.4.

$$t_p = t_{max} - t_0 \tag{1.4}$$

Step Response with PV Controller using High-Pass Filter

The main goal of the simulation was to ensure that the PV controller, with a high pass filter can track the output to the reference signal, and within the requirements (PO<5%, t_p<0.2s, e_{ss}=0). This was done thru simulation in Simulink. A step reference of a square wave with step amplitude of π/4 was generated; the step response was plotted, and the characteristics (PO, t_p, e_{ss}) were found, using equation 1.1-1.4 as explained in the previous simulation. The purpose of the high pass filter was to get rid of high frequency noise in the velocity; this was done in the controller by putting the measured signal (θ_L(rad)) through a High-Pass filter and outputting the velocity since a High-Pass filter is a differentiator; filter replaces the direct derivative block used previously. e_{ss} was found by looking at the plot.

Implementing Step Response using PV Controller

The main goal of the experiment was to ensure that the PV controller can track the output to the reference signal, and within the requirements (PO<5%, t_p<0.2s, e_{ss}=0). This was done thru simulation in Simulink. A High-Pass filter was used to differentiate the output signal (θ_L (rad)) to get the angular velocity, as supposed to taking a direct derivative. A step reference of a square wave with step amplitude of π/4 was generated; the step response was plotted, and the characteristics (PO, t_p, e_{ss}) were found, as explained in the previous simulations, using equation 1.1-1.4. e_{ss} was found looking at the plot.

Results:

Closed-Loop Response with the PV Controller

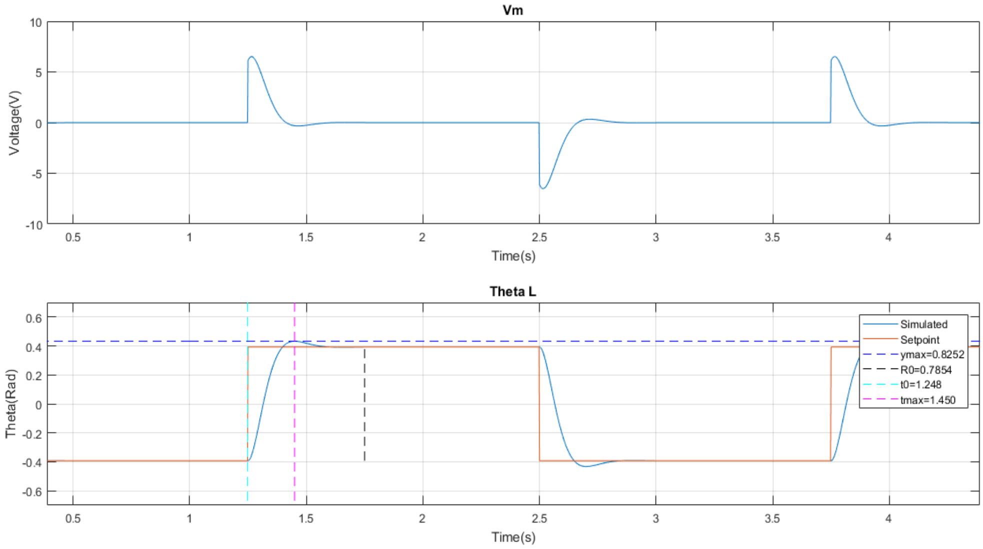

Figure 1: The second-order, simulated step response of the system. max=0.4325 V. initial value=-0.3927 V. y_{ss}=0.3927 V. t_0=1.248 s. t_{max}=1.450 s.

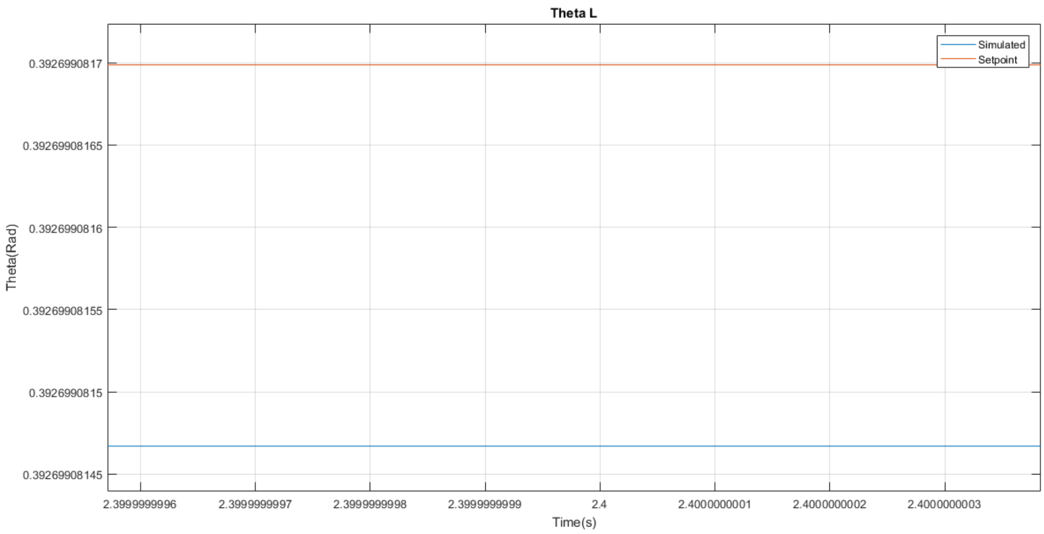

Figure 2: The e_{ss} of the first simulation. error=2x10^-10, 0.95s after peak.The error seems to decrease as time progresses. Therefore, $e_{ss} \rightarrow 0$ as $t \rightarrow \infty$.

Step Response with PV Controller using High-Pass Filter

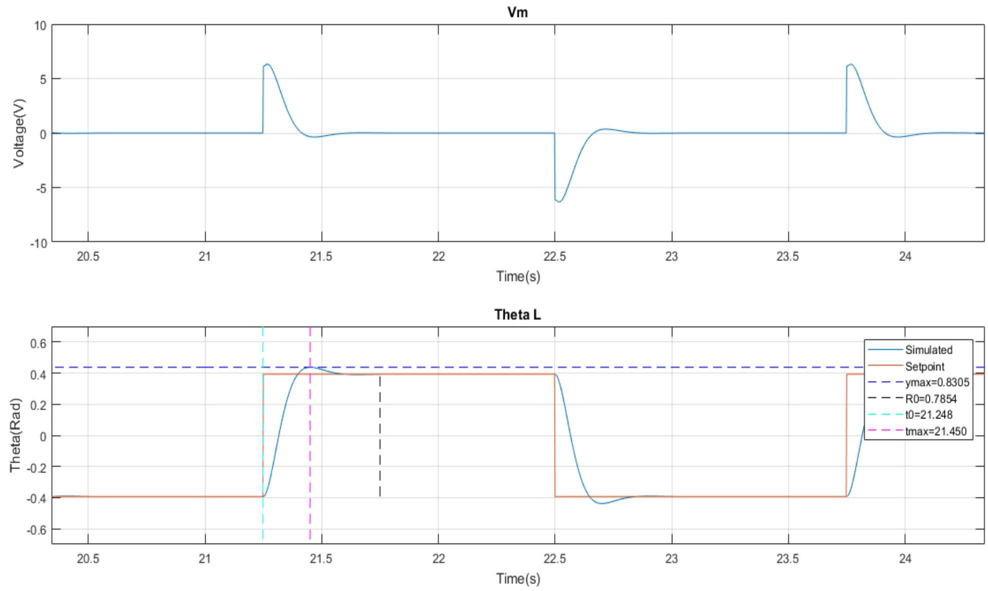

Figure 3: The second-order, simulated step response of the system (using filter). max=0.4378 V. initial value=-0.3927 V. y_{ss}=0.3927 V. t_0=21.248 s. t_{max}=21.450 s.

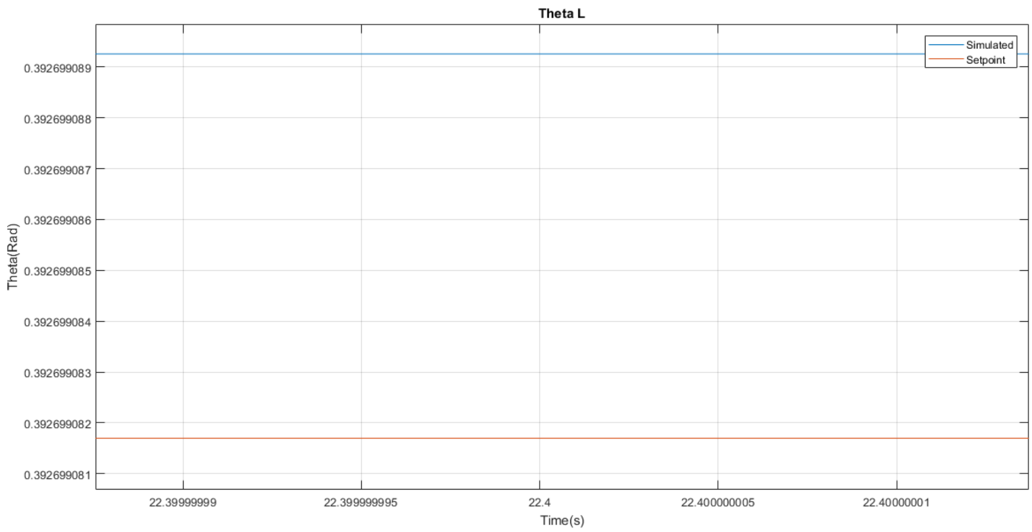

Figure 4: The e_{ss} of the second simulation. e=7x10^-9, 0.95s after peak. The error seems to decrease as time progresses. Therefore, $e_{ss} \rightarrow 0$ as $t \rightarrow \infty$.

Implementing Step Response using PV Controller

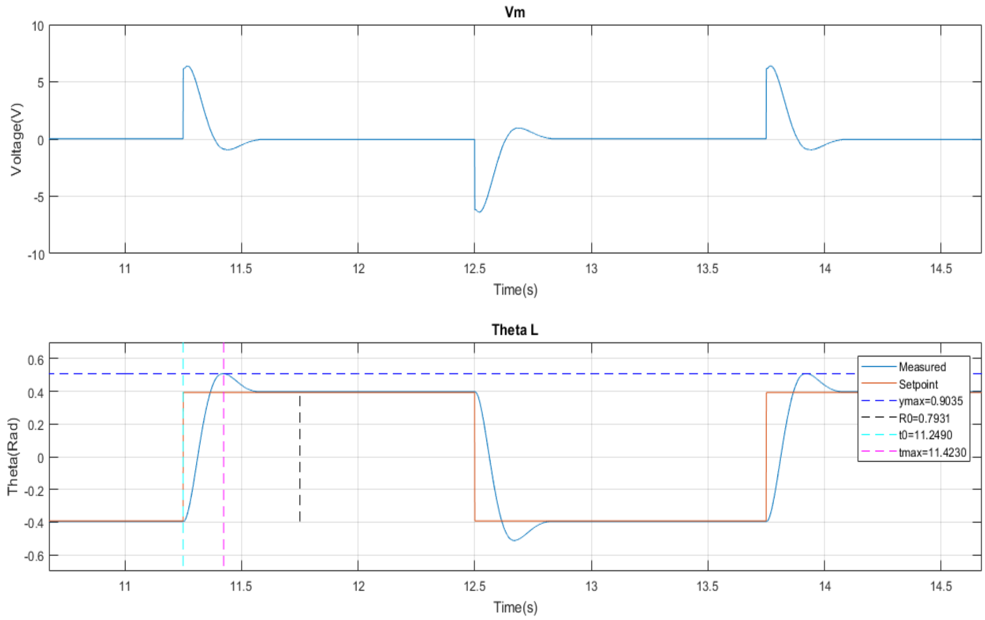

Figure 5: The second-order, experimental step response of the system (using filter). max=0.5077 V. initial value= -0.3958 V. y_{ss}= 0.3973 V. t_0=11.2490 s. t_{max}=11.4230 s.

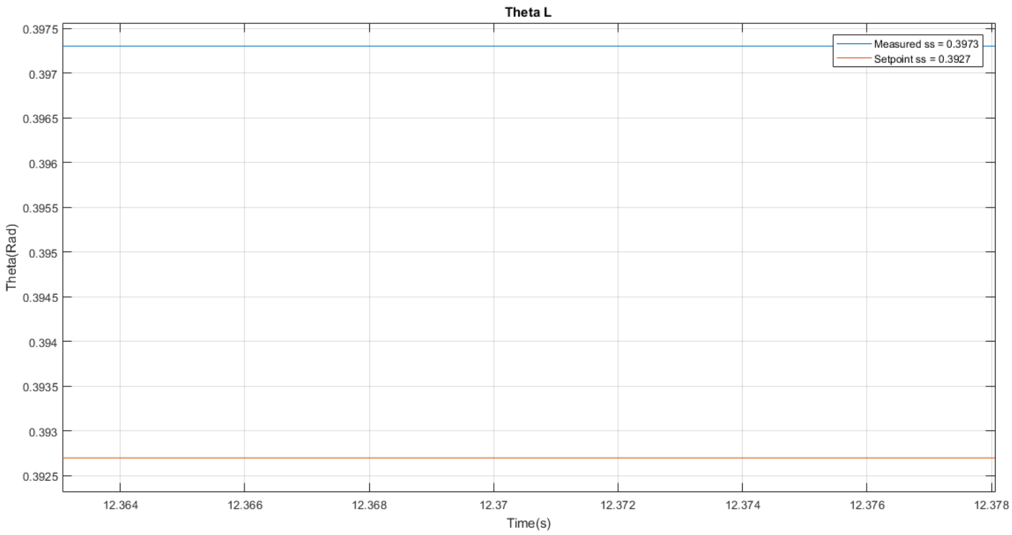

Figure 6: The e_{ss} of the experimental test. e =4.6x10^-3 after 0.95s. Error did not seem to decrease as time increased for the short time frame.

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
Question 4	Pre-Lab: PV Gain Design Proportional gain Velocity gain	k_p k_v	7.8187 -0.1565	V/rad Vs/rad
2.3.1.1	Step Response Simulation Peak time Percent overshoot Steady-state error	t_p PO e_{ss}	0.202 5.07 0	s % rad
2.3.1.1	Filtered step Response Using PV Peak time Percent overshoot Steady -state error	t_p PO e_{ss}	0.202 5.74 0	s % rad
2.3.1.2	Step Response Implementation Peak time Percent overshoot Steady-state error	t_p PO e_{ss}	0.174 13.9 4.6x10^-3	s % rad

Table 1: Properties of the PV controller.

Analysis:

Closed-Loop Response with the PV Controller

Using equation 1.1 and 1.2,

$$y_{max} = \text{max - initial value} = 0.4325 - (-0.3927) = 0.8252 \text{ V}$$

$$R_0 = y_{ss} - \text{initial value} = 0.3927 - (-0.3927) = 0.7854 \text{ V}$$

Using equation 1.3, and 1.4,

$$PO = \frac{100(ymax-R0)}{R0}\% = \frac{100(0.8252-0.7854)}{0.7854}\% = \mathbf{5.07\%}$$

$$t_p = t_{max} - t_0 = 1.450 - 1.248 = \mathbf{0.202\ s}$$

error=7x10^-9, 0.95s after peak. The error seems to decrease as time progresses. Therefore,

$$\mathbf{e_{ss} \rightarrow 0 \text{ as } t \rightarrow \infty}$$

Step Response with PV Controller using High-Pass Filter

Using equation 1.1 and 1.2,

$$y_{max} = \text{max - initial value} = 0.4378 - (-0.3927) = 0.8305 \text{ V}$$

R_0= y_{ss} - initial value = 0.3927 -(-0.3927) = 0.7854 V

Using equation 1.3, and 1.4,

$$PO=\frac{100(ymax-R0)}{R0}\% = \frac{100(0.8305-0.7854)}{0.7854}\% = 5.74\%$$

t_p = t_{max} - t_0=21.450 -21.248 = **0.202 s**

e=7x10^-9, 0.95s after peak. The error seems to decrease as time progresses. Therefore,

e_{ss}→0 as t →∞

Implementing Step Response using PV Controller

Using equation 1.1 and 1.2,

y_{max} =max - initial value =0.5077 -(-0.3958) = 0.9035 V

R_0= y_{ss} - initial value = 0.3973 -(-0.3958) = 0.7931 V

Using equation 1.3, and 1.4,

$$PO=\frac{100(ymax-R0)}{R0}\% = \frac{100(0.9035-0.7931)}{0.7931}\% = \mathbf{13.9\%}$$

t_p = t_{max} - t_0=11.4230 -11.2490 = **0.174 s**

e_{ss}=**4.6x10^-3 rad**

Conclusion:

Closed-Loop Response with the PV Controller

The controller almost meets the requirements (meets e_{ss} requirement, but not PO and t_p); the deviation from the requirements is minor and can be due to measurement error(Matlab or Tachometer).

Step Response with PV Controller using High-Pass Filter

The controller almost meets the requirements(meets e_{ss} requirement, but not PO and t_p); the deviation from the requirements is minor and can be due to measurement error(Matlab or Tachometer). The response is very similar to the first simulation, *Closed-Loop Response with the PV Controller*.

Implementing Step Response using PV Controller

The controller almost meets the requirements(meets t_p requirement not PO and e_{ss}); the deviation from the requirements is minor and can be due to noise in step input and measurement error. The input voltage to the motor does not match the input in the simulation, and this is the reason for why the overshoot is so high. Reasons for why the voltage is different in the experiment from the simulation include:noise between DAQ, and amplifier, and noise between amplifier and motor. The time window to see e_{ss} was short, so it was not possible to definitely conclude the e_{ss}; if the time window was increased, it might be possible to see the e_{ss}.

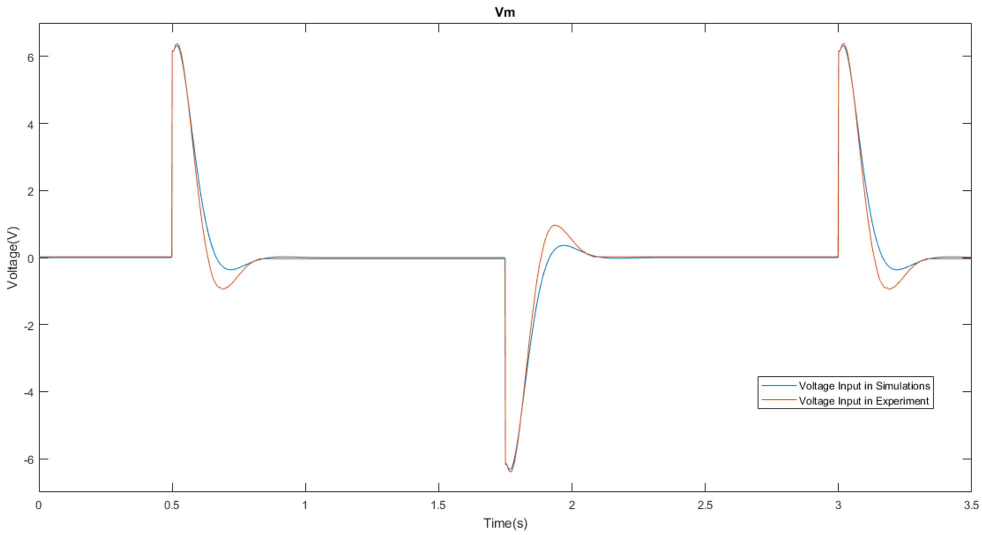

Figure 7:The descripancy between the input voltages for the simulation and the experiment.