AE 443 Speed Control

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AE 443 – Section 03DB

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I. Procedure

I.1. Step. Response with PI Control

The objectives are firstly, to validate desired response specifications under ideal conditions, and secondly, to ensure that the motor remains within operational limits to not become saturated.

To setup the simulation and implementation:

1. Open setup_srv02_exp01_mdl.m
    a. For simulation:
        i. Open s_srv02_spd Simulink
    b. For implementation:
        i. Open q_srv02_spd Simulink
2. In .m, enter proportional and integral gains found in section 1.2.2
3. In Simulink,
    a. Set the speed reference signal to 0.4 Hz square between 2.5 and 7.7
    b. Set the manual switch to upwards to enable PI control
    c. In the speed control block, ensure amplitude is 2.5 rad/s and offset is 5.0 rad/s
    d. Set run time to 5 sec
4. Run the simulation

I.2. Step Response with Lead Control

To setup the simulation and implementation:

1. Open setup_srv02_exp01_mdl.m
    a. For simulation:
        i. Open s_srv02_spd Simulink
    b. For implementation:
        i. Open q_srv02_spd Simulink
2. In .m, enter lead control parameters found in section 1.3.2
3. In Simulink,
    a. Set the speed reference signal to 0.4 Hz square between 2.5 and 7.7
    b. Set the manual switch down to enable lead control
    c. In the speed control block, ensure amplitude is 2.5 rad/s and offset is 5.0 rad/s
    d. Set run time to 5 sec
4. Run the simulation

II. Results

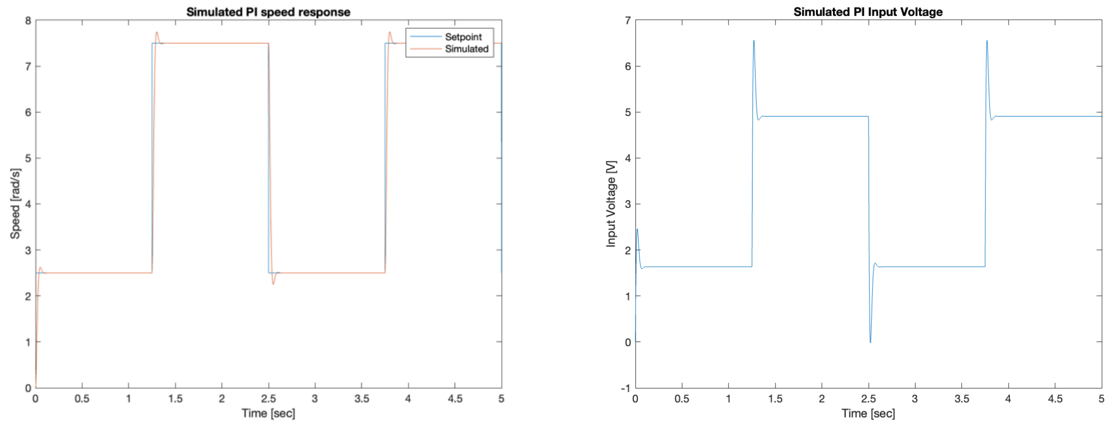

Figure 1: PI Response Speed Simulation

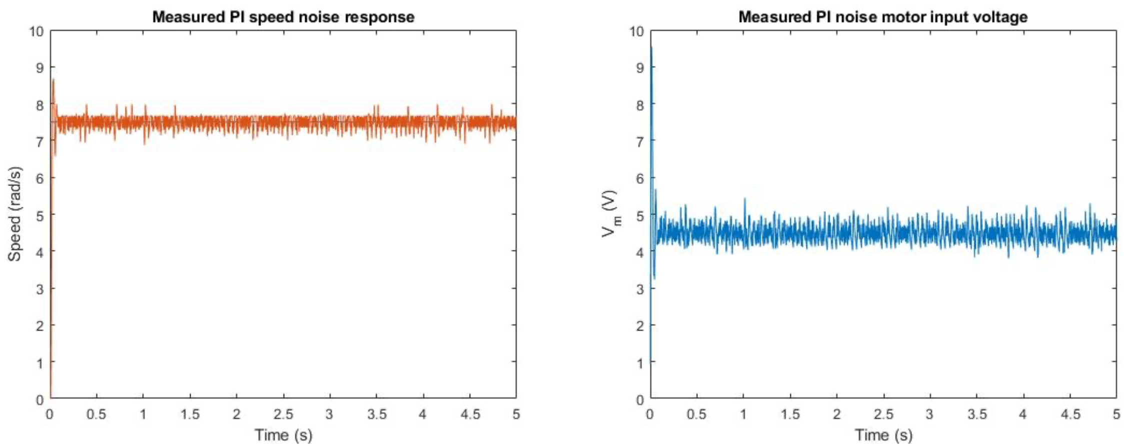

Figure 2: PI Response Speed Noise

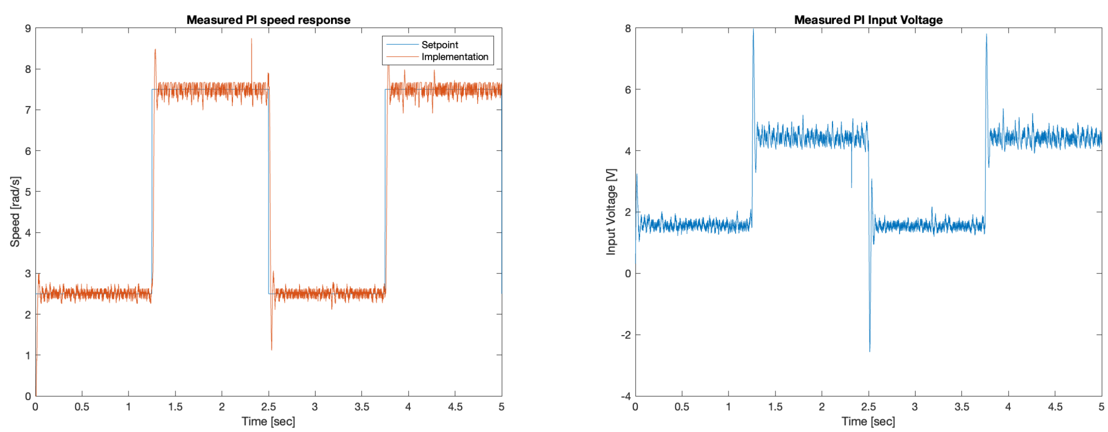

Figure 3: PI Response Speed Implementation

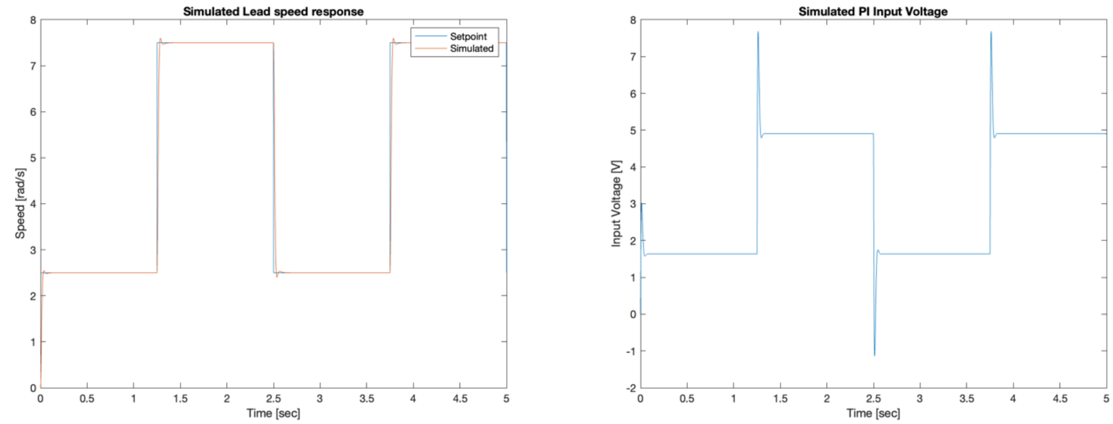

Figure 4: Lead Controller Response Speed Simulation

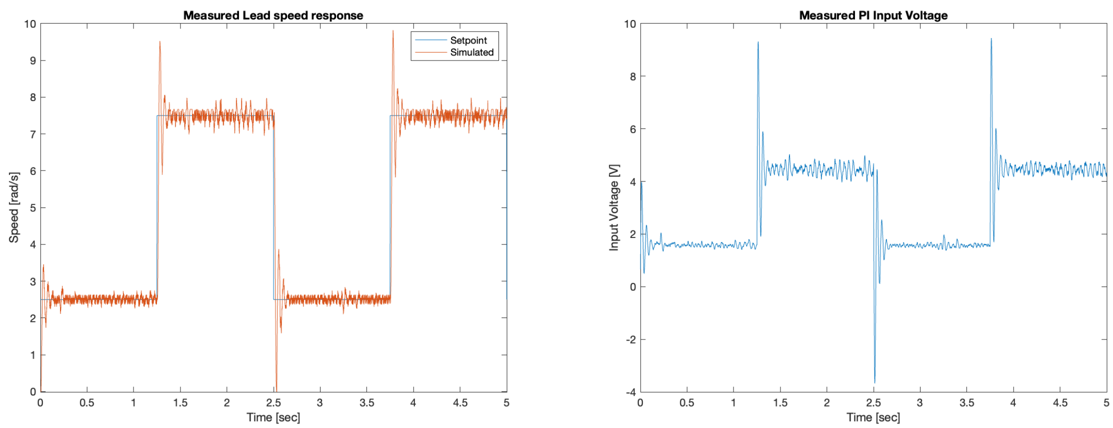

Figure 5: Lead Controller Response Speed Implementation

Description	Symbol	Value	Unit
In-Lab: PI Step Response Simulation Peak Time Percent Overshoot Steady-State Error	 t_p PO e_{ss}	 0.05 3.3367 5	 s % rad/s
In-Lab: PI Step Response Implementation Peak Time Percent Overshoot Steady-State Error	 t_p PO e_{ss}	 0.04 14.27 5.15	 s % rad/s
In-Lab: Step Response Simulation with Lead control Peak Time Percent Overshoot Steady-State Error	t_p PO e_{ss}	0.0362 1.34 5	s % rad/s

In-Lab: Step Response Implementation with Lead control			
Peak Time	t_p	0.034	s
Percent Overshoot	PO	30.92	%
Steady-State Error	e_{ss}	5.0008	rad/s

III. Analysis

$$P(s) = \frac{K}{\tau s + 1} \tag{1}$$

$$P_i(s) = \frac{P(s)}{s} \tag{2}$$

$$s = j\omega \tag{3}$$

$$P_i(j\omega) = \frac{K}{(\tau j\omega + 1)j\omega} \tag{4}$$

$$|P_i(\omega)| = \frac{K}{\omega\sqrt{\tau^2\omega^2 + 1}} \tag{5}$$

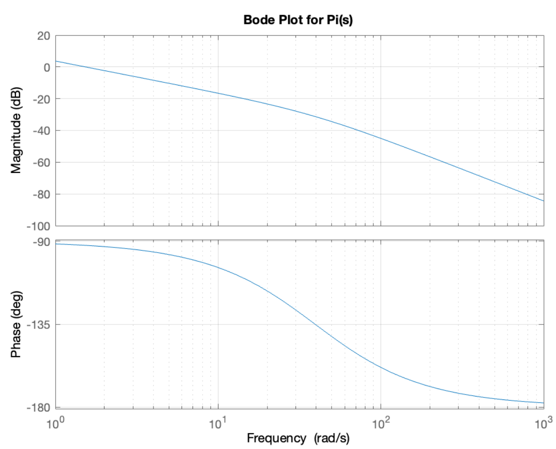

Figure 6: Bode Plot of Pi(s), K=1.53, tau = 0.0254

The system is unstable due to the poles being negative.

III.1 Step Response with PI control

	Percent Overshoot	Steady-State Error	Peak Time
PI control Simulation Implementation	3.3367 14.27	5 5.15	0.05 0.04

The simulation meets specifications for percent overshoot, sse, and peak time. While the implementation does not due to percent overshoot.

Table 1: Section 3.1.2 Step 11

$e_{\omega,meas}$	0.3 rad/s
e_{sse}	0

III.2 Step Response with Lead control

	Percent Overshoot	Steady-State Error	Peak Time
Lead control Simulation Implementation	1.34 30.92	5 5.0008	0.0362 0.034

The simulation meets specifications for percent overshoot, sse, and peak time. But once again the implementation does not due to percent overshoot.

IV. Error Analysis

Description	Expected Value	Measured Value	Percent Error
PI Step Response Peak Time Percent Overshoot Steady-State Error	0.05 3.3367 5	0.04 14.27 5.15	-20.0 76.60 2.90
Step Response with Lead control Peak Time Percent Overshoot Steady-State Error	0.0362 1.34 5	0.034 30.92 5.0008	-6.07 2207 0.01

V. Conclusions

During the experiment, the overshoot was higher with the lead compensator compared to the PI control, contrary to the simulation findings where the lead showed faster peak time and less overshoot. This discrepancy in overshoot is likely due to the noise in the speed signal, where the noisy signal undergoes amplification due to large proportional gain.

Through this experiment, I've gained insights into servo speed control principles, control implementation, and the response to sensor noise. Potential improvements include noise reduction techniques. Errors may arise from either the controllers, mechanisms governing servo speed control or sensor noise.