Laboratory 3 Challenge Submission

Lum Borovci; email: lum.borovci@unipd.it
Group: 86, Shift: 1 (Thursday)

May 19, 2025

1 Required Performance and Controller Design

1.1 Required Performance Specifications

For this challenge, we were required to design a Controller which achieves the following:

- Asymptotic Tracking of Step References
- $Mp \leqslant 30\%$ and minimal $t_{s,5\%}$ for a 50° Step Reference

1.2 Proposed Controller Design

To achieve the performance outlined in Sec. (1.1) we implemented a PID Controller with an Anti-Windup Mechanism, whose gains K_P, K_I, K_D were initially determined using the Bode Method as in LAB 0, and were then tweaked by hand to improve the performance outcome.

The hand-tuning procedure consisted of the following steps:

- Start with $K_P = K_I = K_D = 0$
- Increase K_P until an unstable response is obtained for some K_P^*
- Set $K_P = K_P^*/2$
- Increase K_I until satisfactory t_r, $t_{s,5\%}$ and Mp are obtained
- Increase K_D to reduce Mp

These steps allowed us to find a good set of starting values for the PID constants. After this point the optimization of the values proceeded via trial and error, increasing or decreasing the constants and fixing them one at a time until the best performance possible was achieved.

2 Implementation and Results

2.1 Required Parameters for Setup

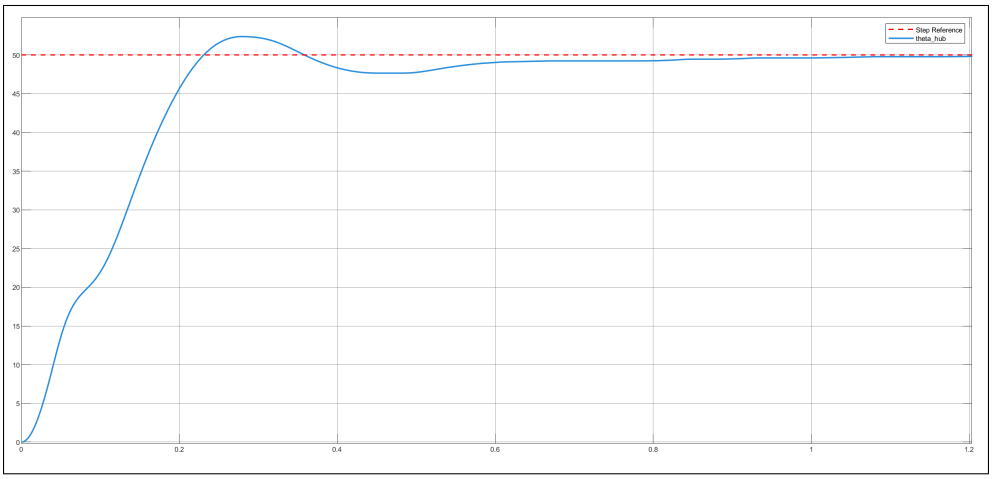
For the Plant setup (the Accurate DC Motor + Hub + Beam Model) the parameters used were the ones reported in the Handout for LAB 3 with the estimated values for $\hat{B}_b = 3.3 \times 10^{-3}$ [Nm/(rad/s)] and $\hat{k} = 0.78$ [Nm/rad].

For the Controller Setup, a separate script which executed PID Tuning via the Bode Method, and also contained the hand-tuned constants, returned the PID and Anti-Windup Gains to the Simulink model as:

$$K_P = 32.30, \qquad K_I = 98, \qquad K_D = 1.84 \qquad K_W = 5.88, \qquad \alpha = 4, \qquad \beta = 0.1$$

2.2 Step Response and Settling Time: Accurate Model

The implementation in Sec. (2.1) achieved a Settling Time of $t_{s,5\%} = 0.21s$ and acquired asymptotic tracking of the 50° Step Reference. The response is displayed in Fig. 1.

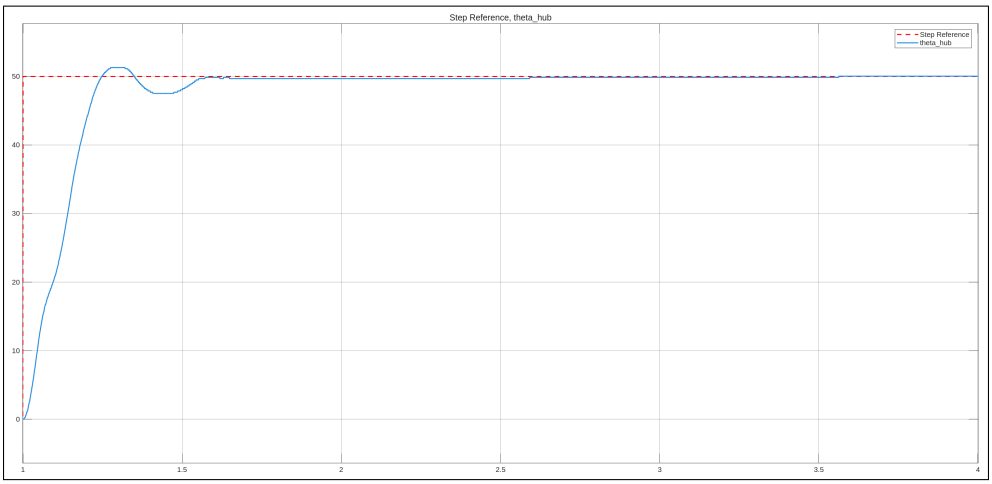


t_r [s]	$t_{s,5\%}$ [s]	$Mp[\%]$
0.1688	0.2121	4.6763

Figure 1: Step response for a 50° reference input: Accurate Model

2.3 Step Response and Settling Time: Real Motor

In the lab environment, the Controller achieved a Settling Time of $t_{s,5\%} = 0.22s$ and acquired asymptotic tracking of the 50° Step Reference. The response is displayed in Fig. 2.



t_r [s]	$t_{s,5\%}$ [s]	$Mp[\%]$
0.1780	0.2230	2.6920

Figure 2: Step response for a 50° reference input: Real Motor