Laboratory report 0: PID Design and Estimation Parameters

Group 2, Tuesday Shift

Baron Davide, Bonetto Alessio, Mustacchi Marco, Piron Luca Vittorio

March 22, 2022

1 Introduction

1.1 Activity Goal

The goal of this laboratory activity is to design a position PID controller for a DC servomotor and to estimate the values of viscous friction τ_{sf}, static friction B_{eq} and the inertial torque J_{eq}.
For the PID design, the Bode's method (explained in Sec. 3.2 of Handout 0) has been used, in order to achieve the following performance specifications:

- perfect steady state tracking of step position (load side) reference
- perfect steady state rejection of constant torque disturbances
- step response (at load side) with settling time $t_{s,5\%} \leq 0.15s$ and overshoot $M_p \leq 10\%$

1.2 Model used

The black box *Quanser_SRV02_block* has been used in order to replace the DC motors physically present in the laboratory and faithfully reproduce the behaviour of the real one.

2 Design of PID-controller

The continous time transfer function of the controller $C(s)$ is:

$$C(s) = K_P + \frac{K_I}{s} + K_D \frac{s}{1 + sT_L} \tag{1}$$

with a real derivative action $\frac{s}{1+sT_L}$ instead of ideal derivative (since the last one is not physically implementable).
For the synthesis of the controller, the Bode's mehod has been used, which leads to the following values:

$$K_P = 8.91 \quad K_I = 81.64 \quad K_D = 0.1218 \quad T_L = 0.0059s \tag{2}$$

However, these parameters need to be adjusted "manually" in order to reach all the required performance specifications. The modified parameters are:

$$K_P = 11 \quad K_I = 40 \quad K_D = 0.125 \quad T_L = 0.0059s \tag{3}$$

These values have been used in order to control the DC motors dynamics and later, to estimate the frictions parameters and the inertial torque parameter.

3 Estimation of Parameters

3.1 Viscous and static friction

For the evaluation of static and viscous friction the procedure explained in Sec 4.1 of Handout 0 has been used. The result of the calculations provide:

$$\hat{B}_{eq} = 1.25 \cdot 10^{-6} Nm/(rad/s) \quad \hat{\tau}_{sf} = 0.0057 Nm \tag{4}$$

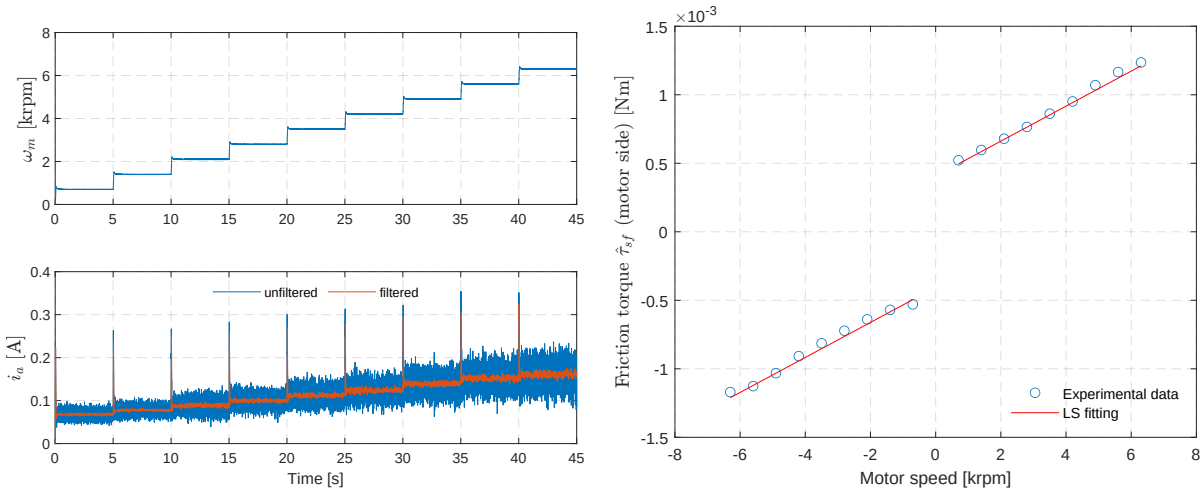

Figure 1: Friction estimation test: (a) experimental data (for positive speed profile); (b) LS estimation of friction parameters.

3.2 Inertial torque

For the evaluation of inertial torque component, the procedure explained in Sec 4.2 of Handout 0 has been used. The result of the calculations provide:

$$\hat{J}_{eq} = 5.63 \cdot 10^{-7} Kg \cdot m^2 \tag{5}$$

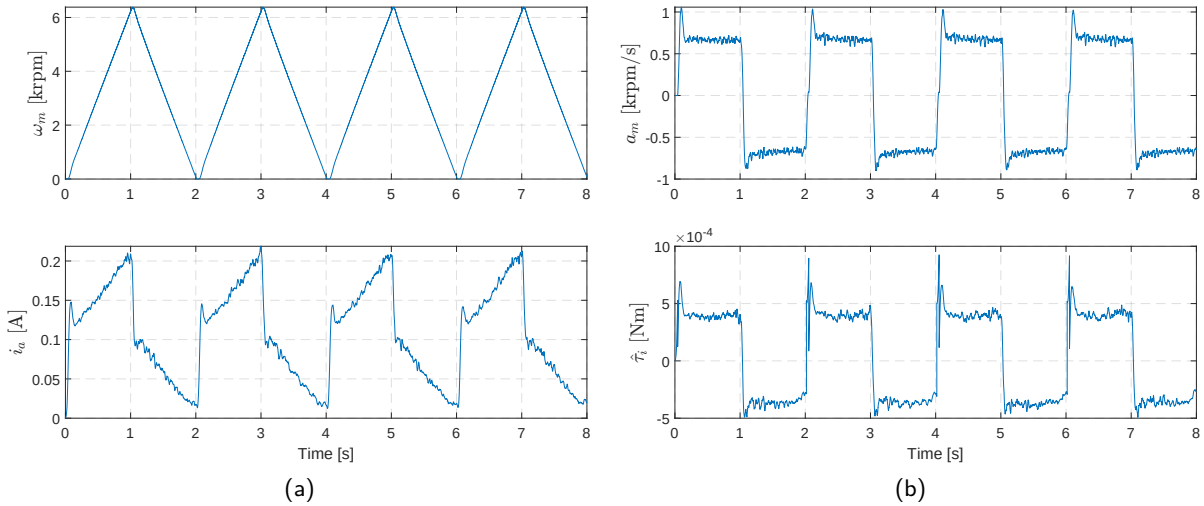

Figure 2: Inertia estimation test: (a) speed and current profiles; (b) acceleration and inertial torque profiles.