Laboratory report 0: PID Design and Estimation Parameters

Group 2, Tuesday Shift

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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

For the estimation of friction and inertia values, the actual DC motor in the laboratory was used (in particular the motor number 02). On the other hand, the black box *Quanser_SRV02_block* has been used in order to compute the PID controller gains.

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:

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

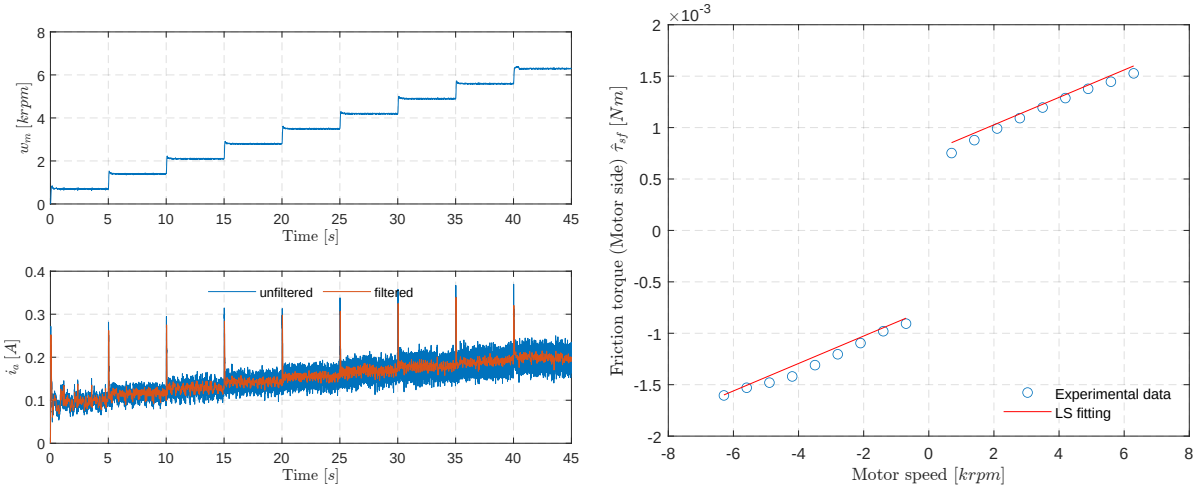
These values have been used in order to control the DC motors dynamics and later, to estimate the frictions parameters and the inertial torque parameter.

3 Estimation of Parameters

3.1 Viscous and static friction

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

$$\hat{B}_{eq} = 1.2745 \cdot 10^{-6} Nm/(rad/s) \quad \hat{\tau}_{sf} = 0.0106 Nm \tag{4}$$



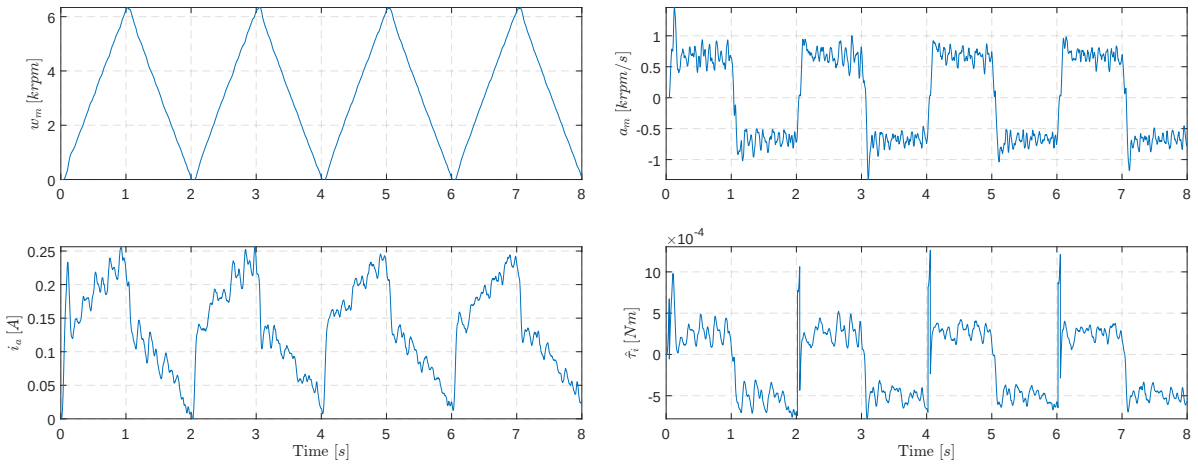
(a) (b)

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

3.2 Inertial torque

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

$$\hat{J}_{eq} = 5.5567 \cdot 10^{-7} Kg \cdot m^2 \tag{5}$$



(a) (b)

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