Laboratory report 3: Challenge

Group 2, Tuesday Shift

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

May 10, 2022

1 Introduction

1.1 Activity Goal

The goal of the challenge of this laboratory is to design a control system for QUANSER SRV-02 MOTOR such that:

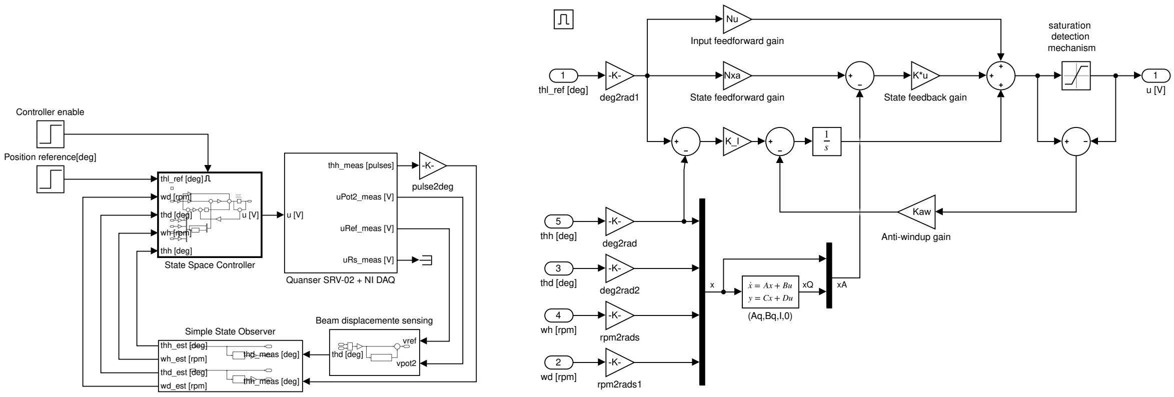
- It ensures asymptotic tracking of step references;
- It ensures an overshoot $M_p \leq 30\%$ for a 50deg step reference;
- It attains the shortest settling time $t_{s,5\%}$ you are able to achieve for the same reference;

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 Choice of control technique

Among the possible solutions a control in state space has been chosen. The state space controller has been chosen instead of a PID controller because considering a state space reppresentation is possible to implement a LQR controller.
In order to avoid resonances cause by the oscillating beam is possible to introduce a frequency varing control, called *frequency shaped* control.
Cleary, to ensures asymptotic tracking an integral control has been added in order to reduce the error modelling and the friction of the motor.



(a) (b)

Figure 1: Simulink model used: full system with simple observer and a beam displacement sensig module (a); LQR-FS controller with integrator and feedforward compensation (b).

To reduce the overshoot caused by the integrator, an anti-windup feedback gain has been added.

3 Choice of Parameters

The controller evaluation has been done following the procedure explained in Sec. 6.4 of Handout3. Through a trial-and-error approach, the principal parameters has been choiched:

- $N_u = 0$ [input feedforward gain]
- $N_{x_A} = [0.8 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0]^T$ [state feedforward gain]
- $\omega_0 = 34.3294$ rad/s [frequecy of notch filter]
- $\bar{\theta}_h = 0.0899$ rad [Bryson's weight for θ_d]
- $\bar{u}_h = 3$V [Bryson's weight for control u]
- $q_I = 896$ [cost associated with the integrator state]
- $q_{22} = 4$ [weight for beam displacement θ_d]
- $K_{aw} = 2.5$ [anti-windup gain]

Then, the following matrices have been used for the extended model:

$$A_Q = \begin{bmatrix} 0 & 1 \\ -1178.5 & 0 \end{bmatrix}, \qquad B_Q = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \tag{1}$$

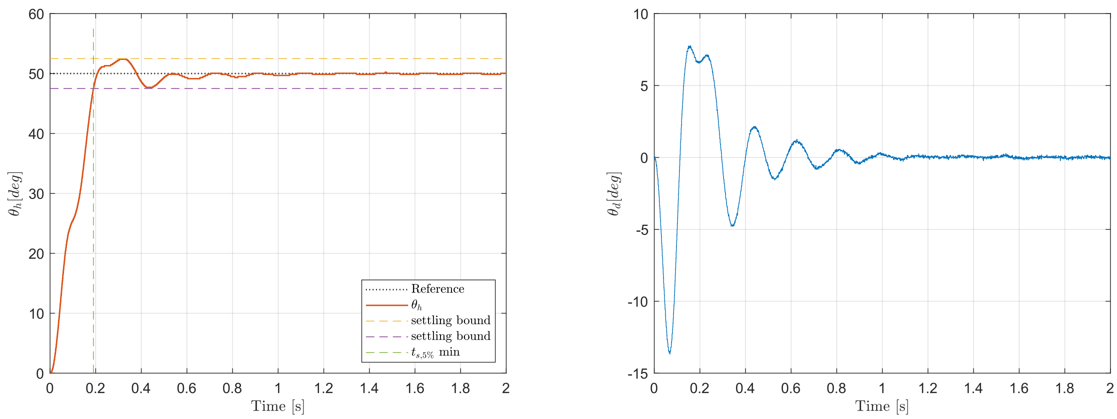
The augmented-state feedback control gains and integral gain, K and K_I are obtained using command *lqr* of matlab toolbox:

$$K = [40.08 \quad 4.72 \quad 2.42 \quad 0.986 \quad 2135.5 \quad -196.36] \qquad K_I = 89.8 \tag{2}$$

4 Results

The best performances that the system is able to achieve with the chosen controller are:

$$t_{s,5\%} = 189.98\,ms \quad M_p = 4.76\% \tag{3}$$



(a) (b)

Figure 2: Step response to 50deg reference: hub displacemente (a), beam displacement (b)