Laboratory report 1: Challenge

Group 2, Tuesday Shift

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# 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 $M_p \leq 10\%$ for a 70deg step reference;
- It attains the minimum raise time $t_r$ you are able to achieve

## 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 through a feedback it is possible to allocate more precisely the poles' location.
In order to reduce the overshoot for the step reference this controller has been modified by adding an anti windup control.

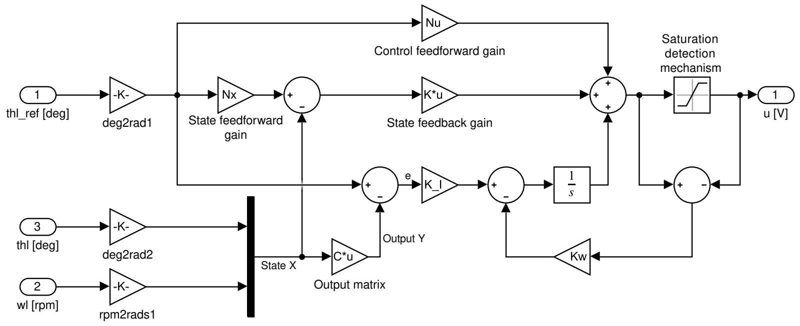


Figure 1: Simulink model of integral control in state space with anti windup compensation

# 3 Choice of Parameters

The choice of poles' allocation and the anti windup gain $K_w$ is made through a trial-and-error approach.
First of all, the poles' allocation has been chosen in order to increase the control and obtain the

minimun raise time the system is able to achieve.
After that, the anti windup gain has been chosen in order to reduce the overshoot peak amplitude. Balancing the two features, the poles and anti windup gain have been obtained:

$$\lambda_{c\{1,2\}} = -60 \pm 27.2875 \quad \lambda_{c,3} = -80 \quad K_w = 46.25 \tag{1}$$

The poles' location imposes the control matrices K and $K_I$:

$$K = [74.2016 \quad 0.8726] \quad K_I = 1849.5 \tag{2}$$

# 4 Results

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

$$t_r = 35ms \quad M_p = 5.94\% \tag{3}$$

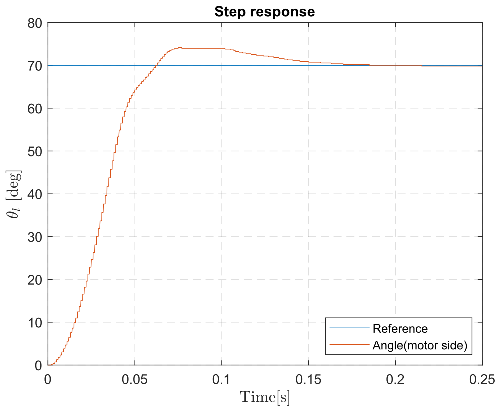


Figure 2: Step response to 70deg reference.

# 5 Remarks

A couple of observations worth highlighting were made when adjusting the controller:

- A reduced order observer should reduce the computational cost to reconstruct the state of the system, albeit the performance of the whole system remains substantially the same.
- Perhaps an LQR control should be the most efficient solution to the problem, since the trade-off between speed and the extent of the overshoot peak is best implemented by this type of control.
- Through a parametric simulation on the poles' position it is possible to see that at a certain point the response to the step caused steady oscillations. Instead of taking the response at the limit before the oscillations, we preferred a response with a slightly higher rise time, but much smoother and with a much lower overshoot (by 3 %).

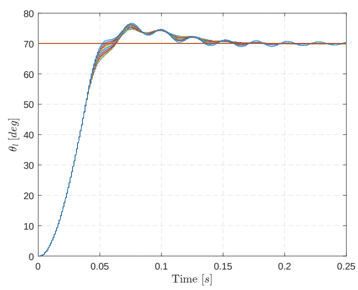


Figure 3: Parametric response

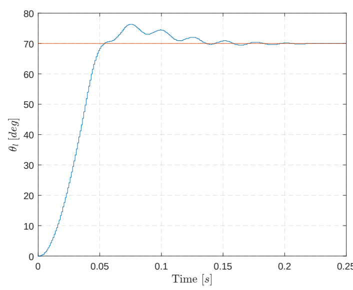


Figure 4: Discarded response