Laboratory Challenge 1:

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Group: 7, Thursday shift

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1 Approach

To meet the design requirements, we used a control architecture combining a PI controller with anti-windup. To minimize the rise time, we added an initial feedforward action. The schematic of the control architecture is shown in fig. 1.

2 Design and Results

2.1 Controller Design

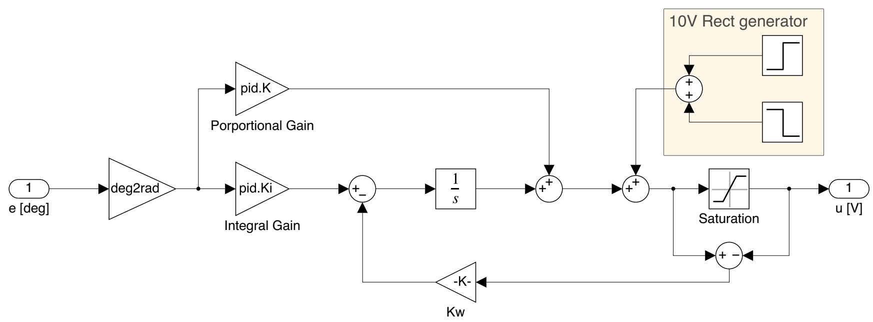


Figure 1: Controller Design using a combination of PI, anti-windup and an initial feedforward rectangle action.

In order to get shortest possible rise time we used as feedforward action an initial rectangular control input. We applied the maximum possible control action of 10 V for a fixed amount of time t_s, which we subsequently tuned. The initial saturation of the control action can be seen in fig. 2a. This, with the integral action of the controller, may generate an uncontrolled overshoot. To limit the effect of this phenomenon, we have considered also an anti-windup mechanism, with gain Kw. After the initial feedforward action is terminated, the control action is determined by only the PI controller. This guarantees that we can track a step reference with zero steady-state error.

In total, this control architecture has 4 parameters to tune: the proportional and integral gain of the PI part K and K_i, the anti-windup gain K_w and the duration of the initial control action t_s. We first tuned t_s to achieve minimum rise time. Afterwards, the anti-windup gain K_w and the proportional gain K were tuned to reduce overshoot.

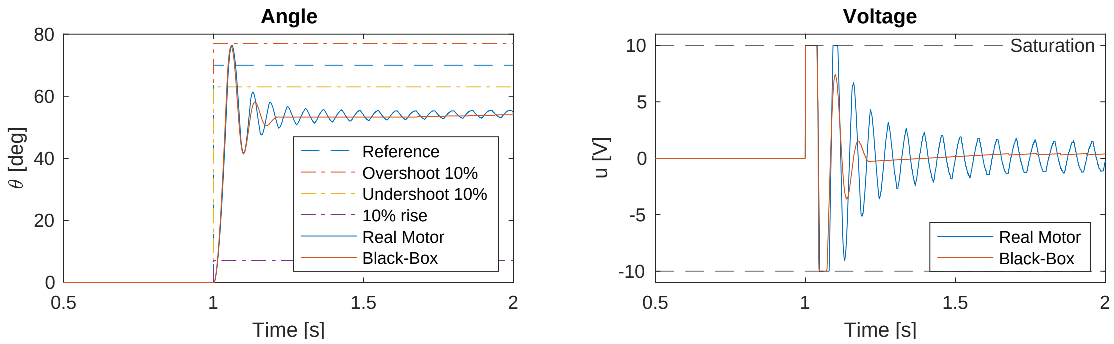
K	Ki	Kw	t_s
38	5	13.33	43ms

K	Ki	Kw	t_s
65	5	13.33	48ms

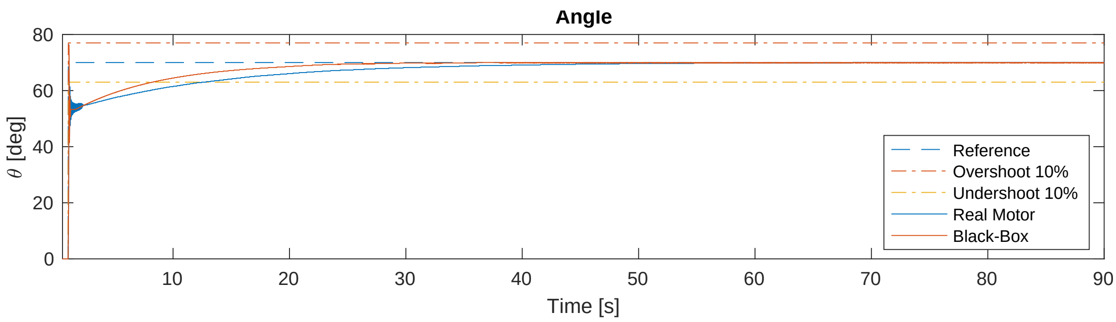
Table 1: Final parameters choice: black-box on the left and real motor on the right.

2.2 Results

Simulation and experimental results, on the black box model and the real motor[1], for a step reference of 70° at 1s are shown in fig. 2a,2b. The achieved performances are summarised in table 2.



(a) Step response on the left and control voltage on the right.



(b) Steady-state tracking of the reference.

Figure 2: Results for black-box and real motor for a step reference of 70°.

Rise time[2]	Overshoot
0.031s	8.77%

Rise time	Overshoot
0.034s	9.03%

Table 2: Achieved rise time and overshoot: black-box on the left and real motor on the right.

2.3 Discussion

Assuming the plant is LTI, we can argue that our controller can achieve the minimum possible rise time. Indeed, as the impulse response of the plant is positive, the maximum possible input for an interval of time will give the maximum possible value of the output at the end of that interval. Therefore assuming a sufficiently large t_s we can achieve the minimum rise time.

[1]The stronger oscillations on the real motor are due to the higher choice of proportional gain K

[2]Precision rounded to a millisecond since the sampling time is 1ms, and therefore the digits after are just results of interpolation