EMOMA – homework 2 (no. 13)

1. Make a model of a single–link manipulator for the following data:

   $J_m = 6.1e^{-4}$ kg·m^2;
   $K_b = 0.105$ V/(rad/s);
   $K_m = 0.105$ N·m/A;
   L = 0.9 e-3 H;
   R = 0.76 Ω;
   $B_m = 4e^{-4}$ N·m/(rad/s);
   gear ratio r=156;
   under saturation limits of the manipulator input signal: V_{min} = –35 V, V_{max} = 35 V.

2. Simplify the model neglecting the electrical time constant, simulate both the accurate and the simplified models using the step or pulse input signal (for the position) and make the comparison plotting outputs of both models (preferably in one figure) and the difference.

3. Assuming that both position and velocity are measured, design the PD controller satisfying the requirement: maximal control error (i.e, the difference between the cubic polynomial reference trajectory and the manipulator output trajectory) should be between 0.01 and 0.005, for the cubic polynomial trajectory from $\theta_s = 0$ [rad] to $\theta_s = 0.5$ [rad], with initial and final velocity equal to zero and time of movement $t_f = 1$ (starting at t = 0).
   Check behavior of the PD control system for the step change of the constant reference trajectory from $\theta_s = 0$ to $\theta_s = 0.5$ (modify the control system structure !).

4. Test the behavior of the PD control system for the LSPB trajectory from $\theta_s = 0$ to $\theta_s = 0.5$, with the same time of movement t_f as for the cubic polynomial trajectory and with the blend time $t_b = 0.2t_f$, assuming initial and final velocities equal to zero.

When doing the comparison in points 3 and 4, plot in the same figure desired and actual trajectories of the arm position (one figure) and of the arm velocity (second figure). Plot the control error (third figure).

5. Check influence of the constant load disturbance equal to $\tau_l/r = 2$ N·m, for cubic and LSPB reference trajectories.

6. Design the PID controller, under the same design requirement as for the PD controller, test the behavior of the resulting feedback control system for cubic and LSPB reference trajectories, for situations without and with load disturbance as in point 5. Check behavior of the PID control system for the step change of the constant reference trajectory from $\theta_s = 0$ to $\theta_s = 0.5$ (modify the control system structure, use anti-windup if needed).

7. Add the feedforward action to the PID feedback control system and test it for sinusoidal arm reference trajectory with amplitude $\theta_{smax} = 0.25$ [rad] and angular frequency $\omega^{ref} = \omega/5$ [rad/s] where ω is the value of angular frequency chosen in point 6 for PID tuning, plot the output and reference trajectories in one figure and control error in another one. Compare with the feedback only PID control (without feedforward) plotting analogous figures for the same sinusoidal reference trajectory.

The report should be submitted by January 24th 2021 at the latest, as a single "pdf" (or "doc") file, to the "Reports" module on the EMOMA course page on the server Studia III (the server will not accept transmission after the deadline). The report should be concise, do not copy fragments of the lecture notes into the report !