Automatic Control - Laboratory 4
Motion control - Standard control techniques
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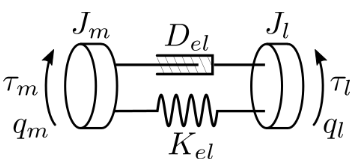


Consider a servomechanism characterized by the following parameters (SI units):

- motor moment of inertia, $J_m = 1.5 \cdot 10^{-4}$;
- transmission ration, $n = 100$;
- viscous friction coefficient, $D_m = 0.0034$;
- load moment of inertia, $J_l = 2.7$;
- transmission stiffness constant, $K_{el} = 3.05$;
- transmission damping, $D_{el} = 0.0022$.

Assuming as state variables motor position and velocity, and load position and velocity, and as output variable motor side position, the state-space model of the servomechanism is described by the following matrices

$$A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -\dfrac{K_{el}}{J_m} & -\dfrac{D_m + D_{el}}{J_m} & \dfrac{K_{el}}{J_m} & \dfrac{D_{el}}{J_m} \\ 0 & 0 & 0 & 1 \\ \dfrac{K_{el}}{J_{lr}} & \dfrac{D_{el}}{J_{lr}} & -\dfrac{K_{el}}{J_{lr}} & -\dfrac{D_{el}}{J_{lr}} \end{bmatrix} \qquad B = \begin{bmatrix} 0 \\ \dfrac{1}{J_m} \\ 0 \\ 0 \end{bmatrix}$$

$$C = \begin{bmatrix} 1 & 0 & 0 & 0 \end{bmatrix}$$

where $J_{lr} = J_l/n^2$.
This laboratory aims at designing a motor side and a load side P/PI control architecture, and compare the results of the two motion control systems.

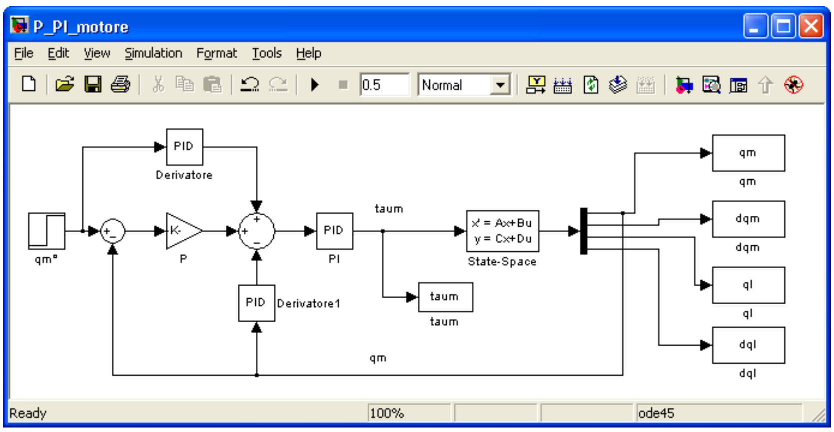
1. Compute the transfer function $G_{vm}(s)$, from motor torque to motor velocity, and the natural frequency ω_z and damping ξ_z of the zeros.

2. Using `rltool`, import the plant transfer function ($P = G_{vm}$) and create a compensator with an integrator and a zero at frequency $\omega_z/10$. Analyse the step and impulse responses, and the frequency response of the closed-loop system for different values of the controller gain. Select the gain so that the damping of the closed-loop poles is maximised. Using this gain compute the ratio $\tilde{\omega}_{c_v}$ between the crossover frequency computed using the rigid model and the frequency ω_z.

3. Compute the closed-loop transfer function $F_v(s)$ of the velocity loop, and the transfer function seen by the motor side position controller $G_{pm}(s) = \dfrac{F_v(s)}{s}$.

4. Using `rltool`, import the plant transfer function ($P = G_{pm}$) and select a gain for the proportional regulator so that the damping of the closed-loop poles is 0.7.

5. Using the following Simulink diagram, simulate the response of the system to a step on the reference signal.

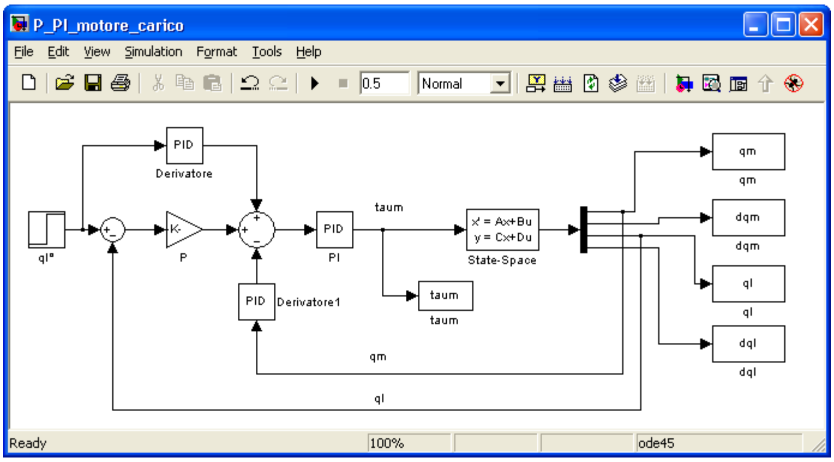


6. Compute the transfer function seen by the load side position controller $G_{pl}(s) = \frac{F_v(s)}{s} G_{lm}(s)$, where

$$G_{lm}(s) = \frac{1 + \frac{2\xi_z}{\omega_z}s}{1 + \frac{2\xi_z}{\omega_z}s + \frac{s^2}{\omega_z^2}}$$

7. Using `rltool`, import the plant transfer function ($P = G_{pl}$) and select a gain for the proportional regulator so that the damping of the low-frequency closed-loop poles is 0.5.

8. Using the following Simulink diagram, simulate the response of the system to a step on the reference signal.



Compare the results achieved with the motor side and load side position loop.