Cascade Control Algorithm of the Servormotor Drive of Robotic Arm

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Abstract. In this paper is synthesized the control algorithms in cascade control systems. The control object is the robotic arm which is actuated by a servo motor presented as a cascade control system which is consisting of two loops. The use of multiple loops is justified by the fact that with a single loop, only one parameter of the servo motor is controlled, which leads to a decrease in the reliability of the automatic system.

It is considered given the mathematical model of a servo DC motor with permanent magnets, which is described by the second order with astatism transfer function:

$$H_M(s) = \frac{k}{s\left(T_m T_e s^2 + T_m s + 1\right)}, \tag{1}$$

where k is the transfer coefficient, T_m – electromechanical time constant, T_e – electrical time constant.

Cascade control structures are used for control fast and slow processes with or without time delay. The presence of a big number of time constants in the transfer function of the fixed part makes it difficult to use some typical control algorithms imposing the compensation of these time constants, by the control algorithms that are containing several first degree binomials. The structural block diagram of the automatic control

system for the servo motor angle with two loops is shown in Figure 1 [1], [2].

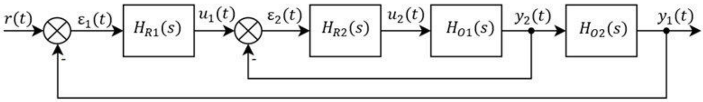

Fig. 1. Structural block diagram of the two-loop automatic control system

According to the structural block scheme of the DC motor with permanent magnets, the expressions for the parts $H_{01}(s)$ and $H_{02}(s)$ of the control object are following:

$$H_{01}(s) = \frac{k_1}{Ls + R}, \tag{2}$$

$$H_{02}(s) = \frac{\frac{1}{Js}}{1 + \frac{1}{Js}k_2} \cdot \frac{1}{s} = \frac{1}{Js^2 + k_2 s}. \tag{3}$$

To tune the controllers in the inner and outer contour, the maximum stability degree method with iterations, polynomial method and the Ziegler-Nichols method are used. For the inner loop, the coil current was chosen as the control parameter, and for the outer loop, the angular displacement of the servo motor shaft [2].

The best results were obtained for the case with a PI controller in the inner loop (rise time 0.024 s, settling time 0.026 s), and a P (rise time 0.278 s, settling time 0.299 s) or PD controller (rise time 0.039 s, settling time 0.046 s) in the outer loop. It is not recommended to use a controller with an integrative component in the outer loop, as this will lead to overshoot.

References

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