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Controller tuning for first- to fourth-order inertia object models with astatic behavior using the polynomial method

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Abstract

This paper describes the procedure for tuning a controller for models of control objects with first- to fourth-order inertia and astatic behavior using the polynomial method, with imposed values of the damping ratio and settling time of the synthesized system. The numerator and denominator polynomials of the transfer function of the object model are factorized into factors with zeros located in the left-hand and right-hand parts of the complex plane.Based on the order of the object model and on the conditions for solving the system of algebraic equations, the physical realizability of the control algorithm, and the robustness of the system, the desired polynomial of the synthesized system of the corresponding degree is constructed. This polynomial contains two polynomials with unknown coefficients, and the degrees of the unknown polynomials as well as the degree of the desired polynomial are determined.From the specified damping ratio and settling time, the dominant poles of the synthesized system are determined, and on their basis the characteristic polynomial of the closed-loop system is constructed. If necessary, additional real poles located on the negative real semi-axis are added as far as possible from the dominant poles in order to ensure the physical realizability of the controller and to satisfy the required system performance.By equating the desired characteristic polynomial with the characteristic polynomial of the constructed system, and by matching the coefficients of the same powers of the variable s on both sides of the equality, a system of algebraic equations is obtained, from which the unknown coefficients and polynomials are determined.Based on the stable components of the object and the determined unknown polynomials, the transfer function of the controller is constructed. Examples of controller synthesis for first- to fourth-order object with astatic behavior using the proposed method are analyzed. The synthesized systems demonstrate high performance and good robustness.

Keywords: *automatic system; controller; controller tuning; system performance; system response; transfer function; tuning methods; tuning parameters*

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