

SELECTION OF STRATEGIES FOR PID-REGULATION

Abstract. The results of synthesis and comparative estimation of different structure systems based on classical and parallel real discrete PID regulators are presented.

Key words: discrete algorithms, system structure, synthesis, correction.

PID-regulators are the most common means of automatic regulation of industrial objects [1-3]. In this case, a great variety of PID algorithms is actually used. The main functions of PID regulators are the formation of a proportional, integral and differential components of the algorithm, which can be combined in different ways, implementing the corresponding structures of the systems. Therefore, the choice of the structure of the system becomes necessary. This task is usually solved based on the experience and analysis of the properties of the algorithm and is difficult to formalize. A few attempts, such as [1], are known to solve this problem based on the characteristics of an object under the most general approach characterized by significant uncertainty. This way the problem remains relevant.

To solve the synthesis problem, the most important is the division of PID regulators into idealized and real and mixed-regulators, in which the gain is included in all components of the algorithm, and regulators with a parallel structure in which all components of the algorithm are formed completely independently. By most authors, these regulators are classified as classic and parallel respectively. It should be noted that systems based on parallel regulators, despite their fairly wide application, have not been studied sufficiently [4].

Discrete classical and parallel real PID-regulators when sampling the integral component by the inverse Euler method, and differential – by trapezoidal method (after its simplification) are described, respectively, by transmitting functions [3]:

$$W_{pid}(z) = K_p \left(1 + \frac{T_0}{T_i} \frac{z}{z-1} + \frac{2T_d N(z-1)}{(2T_d + T_0 N)z - (2T_d - T_0 N)} \right) = W_{pr}(z) + W_i(z) + W_d(z) \quad (1)$$

$$W_{pid}(z) = K_p + \frac{T_0}{T_i} \frac{z}{z-1} + \frac{2T_d N(z-1)}{(2T_d + T_0 N)z - (2T_d - T_0 N)} = W_{pr}(z) + W_i(z) + W_d(z), \quad (2)$$

where K_p , T_i , T_d are gain and steady time of integration and differentiation; T_0 – period of discreteness; $W_{pr}(z)$, $W_i(z)$, $W_d(z)$ – is proportional, integral and differential components of algorithms, the content of which is obvious from the expressions (1), (2); N – is a constant coefficient ($N = 2 \dots 20$).

In a regulator with a parallel structure, any modification of the adjustment parameters changes not only the gain, but also the points of breakage of its asymptotic LACHH, that is, different frequencies will be amplified in different ways. Implementation of discrete PID regulators with parallel structure is provided for algorithmic maintenance of controllers of the majority of leading manufacturers, and in addition to Simulink (Matlab).

For research, an object with $W_o(s) = K_o e^{-\tau s} / (Ts + 1)^2$ model was adopted, where τ – is a delay, T – is a time constant, as well as a one-circuit system with an equivalent discrete continuous PID controller in a sequential correction mode (fig.1). The synthesis of systems based on the PID regulator was performed on the basis of the multi-criteria parametric optimization method, which is realized on the basis of the characteristic equation of the closed system, which, taking into account the specifics of the calculation of systems with discrete regulators [3], is described by the expression:

$$\Delta(s) = 1 + W_p(m, s)W_o(m, s) = 1 + W_{pide}(m, s)W_o(m, s) = 0, \quad (3)$$

where m is the root index of volatility [3].

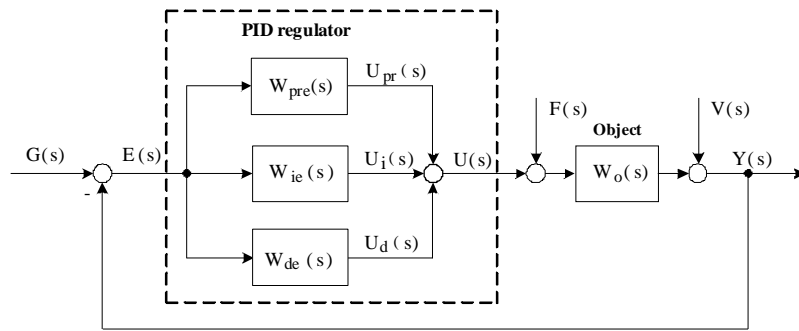


Fig.1. The structure of an equivalent digital continuous system with a PID regulator as a serial correction device

The equation (3) is the same for any method of controller activation in the system. Therefore, for the same parameters, the processes of compensating perturbations are the same, and the processes of working out the task are different. In both cases, the characteristics of the processes depend only on the structure of the regulator and its parameters, as shown in fig. 2.

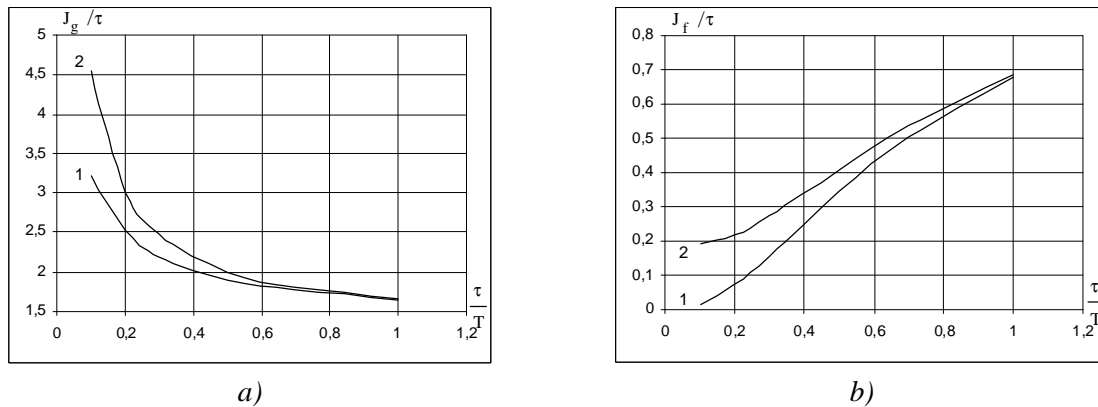


Fig. 2. Characteristics of systems with sequential correction based on real digital classical (1) and parallel (2) PID regulators: J_g / τ , J_f / τ – relative integral quadratic estimates of the quality of processes by task and perturbation

As can be seen from fig.2, the parallel structure is dynamically precisely worse than the classical regulator, and the process of changing the problem and compensating for perturbation, especially at small values of the τ/T object, is also worked out. In this case, the accuracy of compensation of perturbations, which for the systems of stabilization are basic, in systems with a classic regulator and a small inertia of the object is about three times higher than with the application of a parallel regulator. Therefore, the use of a parallel structure regulator, given the dynamic accuracy, is not appropriate. Similar results were obtained for systems with negative feedback – (PI-D.) and (I-PD). The worst dynamic accuracy is characterized by a system based on the (I-PD) algorithm, but it exhibits the highest degree of all known advantages inherent in parallel correction.

In general, the results of the research are obtained in a generalized form, which in many cases makes it possible to determine reasonably when choosing a PID regulation strategy.

Literature

1. D. Xue, Yang Quan Chen, D.P. Atherton. Linear Feedback Control. Analysis and Design with MATLAB. Society for Industrial and Applied Mathematics Philadelphia, 2007.
2. Kovela I.M., Drovetsky V.V., Kovela S.I. Computerized control systems. Monograph. – Rivne: Ovid, 2017 – 672 p.
3. Rotach V.Ya. The theory of automatic control. – M.: Publishing house MEI, 2008. – 396 p.
4. Golinko I.M. Optimization of digital control systems with PI-D- and I-PD regulators // Scientific reports of NTUU «KPI». – 2012. – №2. – S.50-58.