THE METHOD FOR OPTIMAL CONTROL OF HIGH PRECISION QUICK SCANNING SYSTEM

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High-precision, high-speed and reliable control systems form the basis of technological progress in modern information and cybernetic technologies. In particular, it is proposed to use systems with second-order astastism and higher for radars with fast scanning. Then, correctly selected self-tuning parameters minimize the influence of dynamic auto-tuning errors of self-compensating interfering radiation [1]. Similar problems arise when creating high-precision positioning of modern laser systems in medicine, detection and tracking systems for high-speed and highly maneuverable moving objects in other areas of modern technology. Increasing the order of astatism is the most effective way to improve the accuracy of systems. However, high-order astatism significantly affects the damping properties of the system, speed and controllability [2].

As a rule, invariant control methods are implemented using combined control systems. That is, the deviation of the output variable is controlled taking into account the set point and external interference for the system. The technical solutions proposed here [2, 3] provide high accuracy of the system with respect to the control function and external interference. The method uses a multi-coordinate impact on the system through its dynamic coordinates. The control takes into account the frequency and dynamic properties of the system and is carried out through a special non-linear filter.

Multi-coordinates action provides good dynamics of movement along a short path and high accuracy. The control algorithm takes into account the frequency properties of the system, the dynamic parameters of the drive and is carried out through a non-linear filter of the 2nd order. A non-linear filter synthesizes 3-coordinate control of systems with 2nd and 3rd order astatism. An example of a block diagram of a device for optimal control of dynamic systems with the 2nd and 3rd order of astatism is presented in Figure 1, and the results of computer simulation in Figure 2.

Thus, the following technical solutions provide optimal control:

1. The rational spectrum of the system control signal. The function of controlling the system in time in accordance with the Fourier transform can be represented by a spectrum of elementary periodic functions. The astatic system to which the control function is directed is characterized by its frequency parameters, and all other frequencies are interferences that excite reactive processes in the system and impair the quality of control. Using only rational frequency spectra of the control function and suppressing excess spectra prevents the occurrence of reactive processes in transient conditions, increases the noise immunity of the system and its quality.

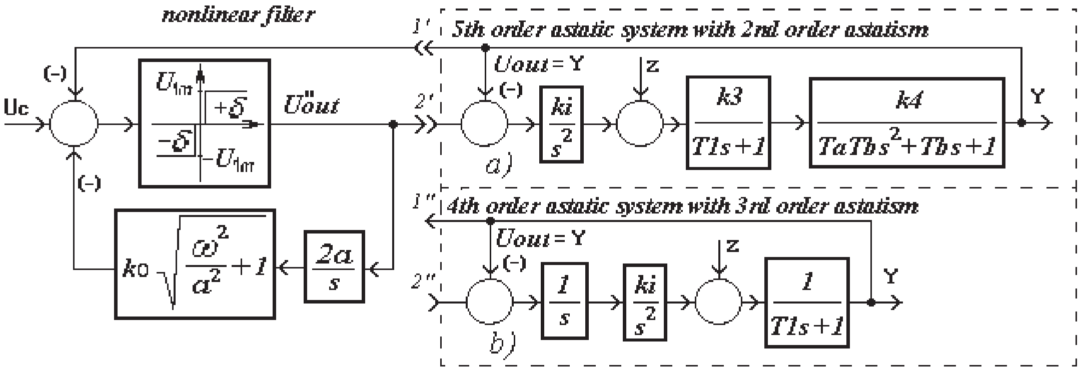

Figure 1. A model of the structural diagram of a control device for systems with astatism of the 2nd, 3rd order. *ω, α, s* – frequency, damping coefficient, Laplace operator

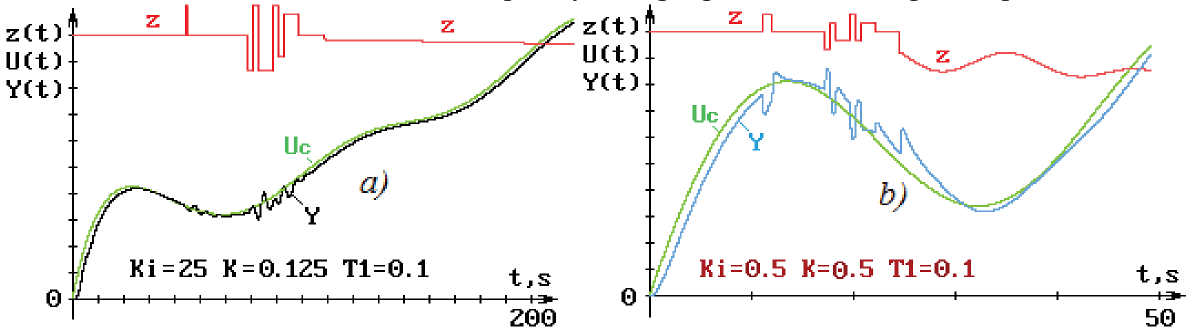

Figure 2. Transient characteristics of systems with astatism: *a)* 2nd order; *b)* 3rd order. Uc – the motion control signal; z – external interference of the system; Y – the controlled coordinate of movement;

2. The choice of system parameters for optimal control. During the movement of the system, the parameters that determine its dynamic properties change, this must be taken into account. In the synthesis of control algorithms for complex systems, approximation methods are used that optimize control by reducing the number of parameters that are difficult to measure. In the proposed technical solutions, the mathematical description of the dynamic properties of the system is approximated by a description based on the frequency parameters of the first harmonic system, which are determined by the sensors. This allows you to effectively manage a complex system even with significant deviations of the calculated parameters from the real ones [2].

3. Speed and energy efficiency. The minimization of the time and trajectories of transient modes is ensured by switching control actions to the dynamic coordinates of the system, starting with the highest derivative of the control function and ending with the control function. In addition, the coordinates are limited by the physical properties of the system, and the beginning of the change in each coordinate corresponds to reaching the limit on the previous coordinate. This ensures the constancy of the sign of the first derivative and a monotonous transition of the main coordinate of motion to a new state [2, 3].

4. Stability (damping) and quality control. The structure of astatic systems includes ***n*** integrating devices that introduce negative phase shifts into the frequency-phase characteristic of the system. Accordingly, the phase characteristic of such a system at any frequency starts with $-n\pi/2$. The necessary margin of stability of the control system and disturbances can be provided by a rational redistribution of poles and zeros of the transfer function or, for example, the introduction of phase shifts in the control function. The presence in the control action of the components of the derivatives of the control function, determined taking into account the frequency properties of the system and the dynamic properties of the drive, provides fixed phase shifts up to $+n\pi/2$, which compensate for the inertial properties of the system and creates the necessary damping

Such damping does not change the amplitude-frequency characteristic of the system, since the frequency transfer function module is introduced by the $|W(j\omega)| = 1$ does not affect the speed of the system and its throughput. This provides compensation for the natural phase shifts of astatic systems without changing their properties [2, 3].

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Анотація

Пропонуються технічні рішення оптимального керування позиціонуванням високоточних і швидкісних динамічних систем.

Ключові слова: оптимальне керування, частотні параметри, астатизм, компенсація фазового зсуву.

Аннотация

Предлагаются технические решения оптимального управления позиционированием высокоточных и скоростных динамических систем.

Ключевые слова: оптимальное управление, частотные параметры, астатизм, компенсация фазовых сдвигов.

Abstract

Technical solutions are proposed for optimal positioning control of high-precision and speed dynamic systems while ensuring astatism and high maneuverability.

Keywords: optimal control, frequency parameters, astatism, compensation of phase shifts.