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Structure of the monitoring and tracking electromechanical control system

***Abstract**. In the presented work, some characteristics of devices of adaptive and control-tracking control systems are considered. The characteristic features of angle sensors, methods of converting analog signals with high accuracy (for example, sine-cosine transformers) occupies a leading position among the development and research of tracking systems. The modern electronic element base opens up new possibilities - the creation of tracking digital angle converters (TDAC) using the principles of digital tracking and adaptive control in them. Stability, efficiency, load form determines the reliability, accuracy, economy, service life of electromechanical automation devices, test equipment, etc. Determining the characteristics, establishing analytical relationships between the initial data and output parameters is one of the stages of the algorithm for solving the problems of designing equipment parameters for monitoring and tracking control systems, which in turn contributes to the development of a mathematical model from a system of equations, the joint solution of which allows you to establish analytical relationships between the initial data and settings.*

***Streszczenie.** W prezentowanej pracy rozpatrzono wybrane charakterystyki urządzeń układów sterowania adaptacyjnego i kontrolno-śledzącego. Cechy charakterystyczne czujników kąta, metody przetwarzania sygnałów analogowych z dużą dokładnością (na przykład transformatory sinus-cosinus) zajmują wiodącą pozycję wśród rozwoju i badań systemów śledzących. Nowoczesna baza elementów elektronicznych otwiera nowe możliwości - tworzenie śledzących cyfrowych przetworników kąta (TDAC) wykorzystujących w nich zasady cyfrowego śledzenia i sterowania adaptacyjnego. Stabilność, wydajność, forma obciążenia określa niezawodność, dokładność, ekonomiczność, żywotność urządzeń automatyki elektromechanicznej, sprzętu testowego itp. Określenie charakterystyk, ustalenie zależności analitycznych między danymi początkowymi a parametrami wyjściowymi jest jednym z etapów algorytmu rozwiązywania problemów projektowania parametrów urządzeń do monitorowania i śledzenia systemów sterowania, co z kolei przyczynia się do opracowania modelu matematycznego z układu równań, którego wspólne rozwiązanie pozwala na ustalenie zależności analitycznych pomiędzy danymi wyjściowymi a ustawieniami. (**Struktura elektromechanicznego układu sterowania monitorującego i śledzącego**)*
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Key words: electromechanical device, adaptive system, tracking system, characteristic, control, signal, input, output, digital, angle converter, electric drive, efficiency, efficiency, reliability, source, phase, amplitude.
Słowa kluczowe: urządzenie elektromechaniczne, system adaptacyjny, system śledzenia, charakterystyka, sterowanie, sygnał, wejście, wyjście, cyfrowe, przetwornik kąta, napęd elektryczny, sprawność, sprawność, niezawodność, źródło, faza, amplituda.

Introduction

The unity of methods of control theory allows to synthesize control systems, has the ability to change the parameters of the controller or depending on the change in the parameters of control objects, or the ability to change the structure of the controller, depending on external influence on the control object. Such control is called adaptive and is widely used in many areas of control theory. Additional possibilities for improving control processes, depending on the size of the input values and designations that come from the measuring devices to the controlled installation, make it possible to carry out non-linear control of the object's activity with a change in the structure of the control installation. In this case, combinations of the laws of a linear regulator can be applied. For example, if, according to the regulation law, the change in the neutral installation is known to be large sequential fluctuations, and according to the law of another linear regulation - weak changes, but a smooth approach to the steady state - then at some point A - first, the connection is made according to the first law, and then - according to second law and the change in y reaches a certain value y_a. As a result, the regulation process is expressed by a curve that combines two qualities of the regulation process - the frequency and smoothness of the process. The application of this approach facilitates the control process in a short period without over-control or without control fluctuations. This is used to control a non-linear system or to control a system with variable parameters. Examples of such systems include asynchronous machines, magnetic bearing vehicles, magnetic bearings, etc. Mechanical systems include the inverted pendulum, lifting and transport machines, robots, steppers, submersibles, etc. Reliability, accuracy and service life of electromechanical devices of control and tracking control systems are determined by the efficiency, stability and shape of the load. For complex control and tracking equipment during testing, these features are one of the important conditions for ensuring accuracy. Monitoring equipment and systems are used to determine the values of physical parameters. Technological processes are characterized by a certain unity of such physical parameters [11-20].

Statement and solution of the problem..

By the nature of the change in the control influence, servo systems are a kind of automatic control system. In tracking systems, the control action is a variable parameter, but its mathematical analysis in time is not determined, since the signal source is external, and the law of its change is not known in advance [15-20]. The control uses the principle of adaptation, which changes all the parameters of the system by the influence of external factors and the movement of the system is subject to quality changes. At the same time, the principles of control do not allow ensuring the normal operation of the system and it is necessary to change the parameters and even the structure of the system in the process of control. As a result of the appointment of servo systems for the execution of the control action at the output with a sufficiently high accuracy, the error is presented as a characteristic and this explains the dynamic features of the servo system. The error in servo systems as a signal, and depending on its value, the actuator is controlled. The control influence is compared with the controlled variable, and so-called comparative elements are used to perform the comparison operation. The control action and the controlled parameter arriving at the inputs of the comparative element must initially change and be given in the form of energy and correspondence signals. These operations are performed by the measuring element from the control action. The control and tracking device consists of a structurally integral whole, not divided into separate parts of the device (for example, a spring pressure gauge for measuring pressure, a mercury glass thermometer for measuring temperature, etc.). Such a device is directly assigned for tracking when processing the incoming information signal. The control-tracking system organizes the unity of measuring instruments (measuring instruments, equipment, converters) and communication channels among themselves, combined auxiliary means, which are determined for tracking when processing signals of incoming information or for automatic processing, or transmission and use in automatic control systems. Each part of the control and tracking system individually plays a decisive role in the independent control process. Control and tracking systems are divided into analog and digital. In analog systems, indicators are functions of changing the tracking parameters, and in digital systems, indicators are presented in digital forms, automatic discrete signals of tracking information are created [1-14].

Corrective devices [6-8] are used to ensure the stability of the automatic control process of the system and satisfy the quality conditions of the control process. As an example, the input value (demodulated) of the shaft rotation angle error Ω with the principle of the servo microcircuit operation algorithm [3-5] ie is given:

(1) $$\Delta U(\Omega,\Psi)=U_0\sin(\Omega-\Psi)$$

If we take into account that the tracking system implements the corresponding calculation process, that is, $\lim_{t\to\infty}\Delta U(\Omega,\Psi)=0$l, then we can apply the "first limit" property $\lim_{\Omega\to\psi}\sin(\Omega-\Psi)$ to calculate the error as a linear you can get the expression:

(2) $$\Delta U(\Omega,\Psi)=U_0\times(\Omega-\Psi)$$

Expression (2) corresponds to a narrow error range (Ω-Ψ) , since formula (1) must be used, which requires equipment, time and software resources. Such a problem is carried out by means of the devices that are part of the microcircuit, for example, using the E-operator method, the problem of the method of synthesizing an alternative algorithm for the tracking digital angle converter (TDAC) is solved. In this case, a transfer function is applied; by changing the speed and angle of rotation of the TDAC shaft, the formation of a digital output signal is taken into account; taking into account the correspondence of the tracking process, the error formation condition is written as system (3):

(3) $$\begin{cases}\left|\Omega-\Psi\right|\le\alpha\text{ at, then }\Delta \mathrm{U}(\mathrm{t},\Omega,\Psi)=\dfrac{1}{\alpha}U_0(\Omega-\Psi)\\ \textit{then }\left|\Delta U(t,\Omega,\Psi)\right|=U_0\end{cases}$$

Figure 1 shows a graph of the error function, and figure 2 shows the structure of the TDAC algorithm [17-20].

$F_{in.}$(p)- input action (demodulated) proportional to the angle of rotation of the shaft; U_1(p), U_2(p)- intermediate signals of the TDAC structure; $F_{out.}$(p)- shaft angle output value; V(p)- the output is the rate of change of the angle of rotation of the shaft. Constants included in formulas (constants):

(4) $$W_1(p)=\frac{k(1+T_1p)}{(1+T_2p)(1+T_3p)}$$

(5) $$W_2(p)=\frac{1}{p}$$

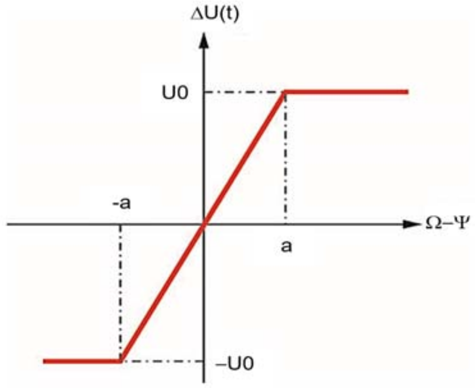

Fig. 1. Graph of the error function

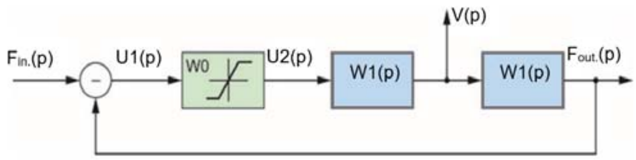

Figure 2. Structure of the tracking digital angle converter algorithm

According to the block diagram in fig. 2:

(6) $$\begin{cases}U_1(p)=F_{in.}(p)-F_{out}(p)\\ U_2(p)\xleftarrow{W_0}U_1(p)\\ V(p)=U_2(p)W_1(p)\\ F_{out}=V(p)W_2(p)\end{cases}$$

The first equation of system (6) corresponds to the algebraic equation:

(7) $$U_1(t)=f_{in}(t)-f_{out}(t)$$

The second equation of the system (6) corresponds to the conditions (3), which are implemented programmatically in the microcontroller. The third equation of system (6) generates the output signal of the rate of change of the angle of position of the output shaft of the TDAC. Given expression (4):

(8) $$V(p)=U_2(p)\times k\frac{(1+T_1p)}{(1+T_2p)(1+T_3p)}$$

Taking into account expression (5), the fourth equation of system (6) corresponds to:

(9) $$F_{out}(p)=V(p)\times\frac{1}{p}$$

In condition (3), equations (7), (8) and (9) express the functioning of the TDAC algorithms. The synthesis of the algorithms of these formulas is applied by the algebraic E-operator method for transforming differential equations, which allows the transformation of linear differential equations, as well as their operator expressions according to Laplace. Therefore, in the transfer function, it is enough to replace the derivatives $(y)^k$ or operators $(p)^k$ with the corresponding expressions as $(1\text{-}E)^{\kappa}/\Delta t^k$, then express the output variable. The resulting expression expresses a linear combination of the values of the output variable that changes over time. The use of the operator E in expression (8) leads to the following equation:

$$V(t) = k_6(U_2(t) \times E \times k_1 + U_2(t)k_2 - V(t) \times E^2 k_3 + V(t) \times Ek_4 \quad (10)$$

A tracking control system is an automatic control system, which, with an unknown law of change in the controlled value, the controlled parameter, is distinguished by an arbitrary influencing feature. The dynamic features of the servo system are determined by the value of the error. In addition, in servo systems, the error signal in the regulation of the object is taken as a signal that depends on the value and nature. Systems are divided into static and astatic. Static systems are controlled by the value of the error: there is an error, there is control in the system. Astatic systems in the presence of a constant parameter error automatically perform their functions. The tracking system can be implemented by various fundamental principles of control and programs, in contrast to software control systems, in such systems, instead of program sensors, a tracking device for monitoring changes in external influences is installed. In tracking systems, the control effect is a variable parameter, but mathematical analysis is not determined in time, since the signal source as an external factor is not known in advance. The error in servo systems covers the dynamic features of the system. In servo systems, the error is received by such a signal that, depending on its value, the actuator motor is controlled [5-16].

Conclusions

On the basis of the scientific and technical base, according to the sources under consideration, an alternative algorithm for the tracking digital angle converter was synthesized. The synthesized adaptive algorithms of the tracking digital angle converter of the second and third kind contribute to a targeted influence on transient processes, while narrowing or expanding the frequency band of the logarithmic amplitude characteristic from zero to the maximum cutoff frequency. Based on cheap modern controllers, the compactness of the presented algorithms allows you to create an effective calculation process using software-apparatus for accurate measurement of the shaft rotation angle. The synthesis of algorithms is carried out by the method of the mathematical E-operator, which, in turn, contributes to the creation of structures with compact algorithms for the construction of real calculation programs. Functional diagrams of control systems for simple dynamic objects, analysis of their definition, capabilities, elemental composition and implemented control principles, as well as the construction of mathematical models of automatic control systems, transformation and research are analyzed. The features and requirements for modeling parameters, the advantages and parameters of the implemented electric drive of control and servo control systems, the main elements of the servo system for the regulation of various electromechanical devices of automation systems are considered.

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