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CONCERNING THE PROBLEM OF NONLINEARITY IDENTIFICATION IN ELECTROMECHANICAL SYSTEMS

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The substantiation of necessity and importance of analysis systems and devices with nonlinear characteristics have been shown. The possibilities of application of the energy method to the problems of identification of electromechanical systems parameters, power diagnostics, and estimation of the quality of power conversion in systems with nonlinear characteristics have been shown.

Key words: instantaneous power method, power diagnostics, identification, nonlinear inductance.

ПРО ЗАДАЧІ ІДЕНТИФІКАЦІЇ НЕЛІНІЙНОСТЕЙ В ЕЛЕКТРОМЕХАНІЧНИХ СИСТЕМАХ

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Представлено обґрунтування необхідності та важливості аналізу систем та пристроїв з нелінійними характеристиками. Показано можливості застосування енергетичного методу в задачах ідентифікації параметрів електромеханічних систем, енергодіагностики, оцінки якості перетворення енергії в системах з нелінійними характеристиками.

Ключові слова: метод миттєвої потужності, енергодіагностика, ідентифікація, нелінійна індуктивність.

PROBLEM STATEMENT. At present one of important directions in electrical mechanics consists in the search of ways allowing one to accurately describe processes caused by the presence of nonlinear elements. Due to the absence of a simple and efficient method of analysis of systems and devices with nonlinear characteristics without significant loss of information relating to electromechanical and power properties of nonlinear objects, creation of theoretical basis for description and analysis of power processes in electromechanical systems (EMS) is topical. This basis will make it possible to obtain the necessary accuracy of estimating the particular features of physical processes in nonlinear circuits.

EXPERIMENTAL PART AND RESULTS OBTAINED. The necessity of getting true data concerning nonlinearity in electromechanical system is caused by the following reasons:

– nonlinearities are typical not only of the most significant structural part of electric machines – electric steel, but also of other links of power conversion – power transforming supply devices of electric motors (voltage transducer, frequency transformer, etc.), kinematic chains of motor and technological mechanism link, actuator of the said mechanism;

– during the process of power conversion the peculiar features of nonlinear elements considerably influence the operation of the technological mechanism, which requires formalization and account. Physical aspects of these features consist in the fact that nonlinearities during the power conversion are the source of its quality deterioration, which results in so-called distortions of voltage and current in the mains, motor moment, i.e. parameters determining electromechanical and mechanical equipment durability and operating capacity;

– deterioration of power conversion quality due to the presence of nonlinearity in the system results in decrease of power efficiency of the equipment because of the growth of power losses in nonlinear and other links.

The above stated is not the dominant element determining interest to estimation of EMS properties caused by nonlinear characteristics of the links, as investigation of devices and systems with nonlinearities appeared quite long ago. In 60-70s of the previous century there was a certain informational outburst in the problems of research of automated control systems with nonlinear characteristics in their structure.

Intensive development of microprocessor and controller systems resulted in creation of a wide range of devices and systems which help both to take nonlinearities into account and to use them for creating automated control systems with expedient or even unique characteristics and properties [1].

The problem of estimation of nonlinearity parameters in the structure of automated control systems, including electromechanical ones, was not considered in detail because theoretical developments, as a rule, were based on generally accepted and often unjustified assumptions; while practical application, from the point of view of gaining the desired effect, was reached at the stage of so-called adjustment.

The necessity of looking for true data concerning elements of automatic control systems, including nonlinear ones, is conditioned to a great degree by practical needs, as the account of the influence of nonlinear elements characteristics is caused not only by their presence, but also by the fact that their parameters are changed in the process of operation depending on a number of factors. Thus, nonlinearities identification is also conditioned by their changing parameters, which is directly connected with the general problem of EMS diagnostics [2].

Lack of attention to the problem of determination of nonlinearity parameters can be explained to a great degree by the difficulties which are unavoidable in theoretical analysis and experimental research of real objects with nonlinear characteristics.

Practice shows that manifestation of nonlinearity is considerably more extensive than it is commonly thought. So, random character processes are based on nonlinear properties of links, and these properties are rather simply described if particular features of objects, processes of power distribution and storage,

environment impact, etc. are taken into account. So, well-known cavitation processes in hydrotransport systems can be regarded as random or as a result of manifestation of some nonlinearities dependant on the volume of transported medium passing during a time unit, its temperature, etc.

These factors, as well as accurate data concerning the object parameters, are the information which is necessary for the research of electromechanical complexes, creating systems for their control, monitoring and diagnostics. Thus, the necessity of identification of nonlinearity parameters, as a separate and independent problem, follows from the above said. This problem is often considered to be a secondary one because of its complexity, namely, due to the absence of a relevant mathematical apparatus allowing one to research and describe power processes taking place in nonlinear circuits.

In reference [3], when circuits with nonlinearities are analyzed, practically all the research is based on some assumptions. Simplification of initial dependences in the analysis results in errors in mathematical representation of the main properties of systems, which manifests itself in further estimation of dynamic conditions and power processes. These errors may be more ponderous than errors existing in formation of components determining power (voltage and current, power and moment etc.).

It is this circumstance that makes it possible to consider power methods of estimation or exact determination of characteristics of automated control EMS nonlinear links to be worthy of notice [2].

The possibilities of EMS parameters identification using power method [4] have been intensively developing in several directions lately. The method is based on the equations of balance of power components of the source and the consumer. The equations are presented in the form of equations of balance of instantaneous power harmonic components. Voltage and current signals in the form of trigonometric series are components of instantaneous power. The main advantage of this approach consists in the fact that the number of identification equations based on instantaneous power components practically always allows one to create an easily solvable system of linear or nonlinear equations with corresponding unknowns.

A classical form of solution to identification problems consists in formation of a test input signal of the simplest form to obtain response functions. Further processing makes it possible to create the mentioned system of identification equations.

The necessity of test signal formation is an obvious disadvantage because it is difficult to put it into practice.

Development of power processes theory using expansion into a trigonometric series of aperiodic functions, functions, assigned at an arbitrary section, enables one to solve the problems of nonlinearities identification by an energy method. The complex of problems to be solved in the first place is the mentioned theory development.

Creating equivalent circuits for nonlinear models, being the basis for description of power processes of both linear and nonlinear elements of the consumer, is equally worthy of special notice.

CONCLUSIONS. The paper presents the necessity for the analysis of electromechanical systems power processes caused by presence of nonlinear elements, as a basis for their mathematical description. It has been shown that a convenient apparatus for obtaining all the necessary indices of power interchange in an electric circuit is presented by a power method that, taking initial data (mains current and voltage) into consideration, makes it possible to create power mathematical models for identification of nonlinearity parameters.

To estimate the influence of nonlinear elements with the aim of obtaining unambiguous, commonly accepted results, when the quality of consumer power conversion is determined, it is necessary to find regularities of power conversion in systems with nonlinearities, taking into account the known phenomenon of current harmonic generation by nonlinear elements.

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О ЗАДАЧЕ ИДЕНТИФИКАЦИИ НЕЛИНЕЙНОСТЕЙ В ЭЛЕКТРОМЕХАНИЧЕСКИХ СИСТЕМАХ

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Представлено обоснование необходимости и важности анализа систем и устройств с нелинейными характеристиками. Показаны возможности применения энергетического метода в задачах идентификации параметров электромеханических систем, энергодиагностики, оценки качества преобразования энергии в системах с нелинейными характеристиками.

Ключевые слова: метод мгновенной мощности, энергодиагностика, идентификация, нелинейная индуктивность.

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