INVESTIGATION OF NONLINEAR PROCESSES IN RADIO DEVICES AS A GUARANTEE OF INCREASE THE QUALITY FUNCTIONING FOR RADIO LOCATION SYSTEMS

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It is necessary to conduct a comparative characteristic of the basic nonlinear processes analysis methods for a reasoned choice methodological basis investigation of amplitude characteristics nonlinearities influence of the real multi-cascade radio receivers on indicators of radio location systems quality. Known theoretical methods of studying these processes are conventionally divided into numerical and analytical methods [1, 2].

A modern classification of the most common methods for analyzing nonlinear processes is presented on Fig. 1.

The general disadvantages of numerical methods are low suitability for establishing general dependencies [2], high development costs and high sensitivity of the final results to the variation of the output data. The last circumstance leads to the need to use very laborious methods of the task regularization. Therefore, numerical methods have limited use for constructive study of the general laws of the radio receivers amplitude characteristics nonlinearities influence on radio location systems quality.

Quasistatic consideration can only be used in those cases, when inertia of the radio device can be neglected. However, this assumption is not always correct for radio receivers of radio location systems, which is especially important in the analysis of the interference off-beam effects.

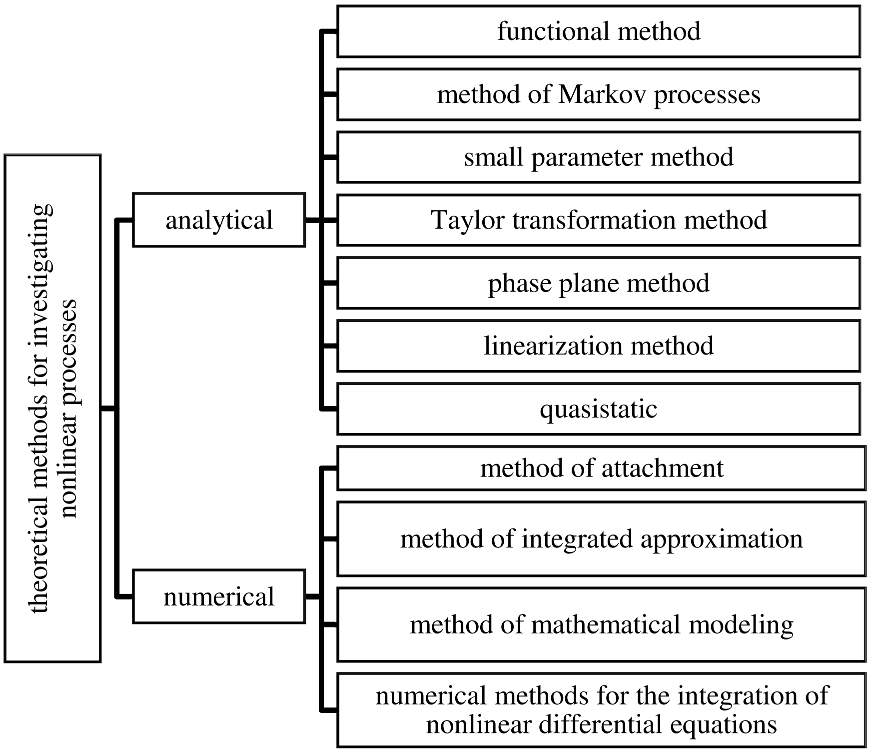

Fig. 1. Classification of theoretical methods for the nonlinear radio location systems study

The phase plane method is used for analysis and research of relatively simple radio receivers only under condition of determinism of input influences and allows you to receive only qualitative results in general [2]. In this regard, this method is practically unsuitable for accurate analysis complex radio receivers of radio location systems the input of which is influenced by stochastic radio location signals and obstacles.

Linearization in the vicinity of the working point is valid only in a very narrow, low-signal region and does not allow to take into account nonlinear properties of radio devices. In this case, the error due to linearization is rapidly increasing in the process of increasing the input signals of radio devices. Therefore, this method is fundamentally not suitable for the study of nonlinear processes on radio receivers of airborne interception radar, which work in a wide dynamic range of input impacts.

The use of harmonized linearization is permissible only in cases, when in radio device contains no more than one nonlinear element with stationary in time of amplitude characteristics and provided the periodic input and output signals with the main frequencies matched [3]. This method does not allow you to investigate the dynamics of radio receivers. Consequently, the method of harmonic linearization is unsuitable for the study of complex multi-cascading radio receivers of radio location systems.

The use of the statistical linearization method is based on the introduction of assumptions and requires a very laborious operation, number of calculations increases sharply with increasing complexity [1]. It significantly limits the possibility of using this method for research of radio receivers of radio location systems in general and for its individual cascades.

The method of combined description functions retains the basic disadvantages of harmonic and statistical linearization methods and is characterized by extremely complex calculations, which means that it is not used [3].

When using small-parameter methods, usually only use the first approximation to the system's solution, which has low accuracy and does not take into account the nonlinear properties of the radio devices [2, 3]. However, finding higher-order approximations is very complicated. Methods of small parameter lose their simplicity and physical visibility the order of which is higher than the second, in addition for the radio devices. Therefore, it is inappropriate to apply these methods for research of radio receivers of airborne interception radar, which represent a multi-cascade connection of nonlinear radio devices with high order.

The Taylor transformation method is used under the condition of deterministic inputs [4], which greatly complicates its application for the study of nonlinear transformations of stochastic radar signals and interference in cascading radio receivers of radio location systems.

The possibilities of the method of Markov processes based on the application of the Kolmogorov-Foker-Planck equations are substantially limited by the considerable volume of complex and cumbersome calculations, which involves the use of the mathematical apparatus of the theory of Markov processes for the analysis of nonlinear radio devices higher than the second order [1, 3]. Therefore, this method is completely unacceptable for the study of nonlinear processes in real complex radio receivers of radio location systems.

From these disadvantages is largely a free functional method [2, 3], which is one of the most effective and promising directions in the theory of nonlinear systems and is based on the representation of the output signal of a nonlinear radio devices in the form of Voltaire's functional series from the input influence [4]

$y(t)=\sum_{i=1}^{\infty}\int_{-\infty}^{\infty}...\int_{-\infty}^{\infty}h'_n(\tau_1,...\tau_n)\prod_{i=1}^{n}x(t-\tau_i)d\tau_i$, or in a multidimensional complex plane

[5] $Y(S_1,S_2,...)=\sum_{n=1}^{\infty}H_n(S_1,...,S_n)\prod_{i=1}^{n}X(S_i)|_{S_i=j2\pi f_i}, \forall i\in[1,2,...]=$

$=Y(f_1,f_{2,...})=\sum_{n=1}^{\infty}H_n(f_1,...,f_n)\prod_{i=1}^{n}X(f_i)$, where $x(\cdot), y(\cdot), X(\cdot), Y(\cdot)$ – in accordance, input and output signals and their Laplace transform (Fourier);

$h'_n g(\cdot), H_n(\cdot)$ – the core of Voltaire n-th order in time and in a multidimensional integrated plane, in accordance (The Voltaire core of the radio unit in a multidimensional integrated plane is usually called its nonlinear transfer function n-th order); $S_i(f_i)$ – argument for Laplace's multidimensional transformation (Fourier); $j=\sqrt{-1}$ – imaginary unit; $\forall$ – generic quantifier.

Possibilities and expediency of the functional method application are due to such fundamentally important advantages of this method as invariance with regard to the type of input impacts [5]; modern and compact control of nonlinear and dynamic properties of radio receivers of radio location systems [3, 5], as well as the possibility of studying both amplitude and phase nonlinear distortions [2, 5]; versatility of the method with respect to various elements of radio receivers the ways of their inclusion, frequency bands, etc [5]; simple connection of criteria for estimating nonlinear properties of radio receivers by characteristics of it nonlinear transfer function; explicit correlation between incoming and outgoing signals of radio receivers [2, 5]; possibility to use both in analytical and computational plans [4]; interpretation of linear systems as a subclass of nonlinear, which allows us to use, during studies of nonlinear processes in radio receivers, well-developed time and spectral methods [3]; the possibility of identification [4]. It can be argued that the functional method is one of the most convenient methods for studying nonlinear processes in radio receivers of radio location systems.

The central and most complex problem is to determine Voltaire's core in the process of practical use of the functional method, which completely and unambiguously describe the properties of nonlinear radio devices and do not depend on the type of input impacts [4]. Therefore, the methods for determining Voltaire's core form the theoretical foundations of the functional method [4].

It is necessary to consider known methods for determining Voltaire's core and choose the most suitable for studying nonlinear processes in radio receivers of radio location systems. However, the known mathematical apparatus has limited capabilities, which is explained by the complications associated with the assessment of the impact of nonlinear dynamic processes on stability and throughput of ultra high frequencies signals [1-4]. From the conducted research there follows the necessity of further development of theoretical foundations of the functional method in the direction of developing a new methodology for the determination of continuous transmitting functions of the radio device that is free from the above-mentioned shortcomings, as well as the substantiation of the methodology for investigating the integral influence of nonlinear processes directly in the most multi-cascade radio receivers.

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