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СИНТЕЗ ОПТИМАЛЬНОГО АЛГОРИТМА ОЦІНКИ РАДІОМЕТРИЧНИХ ЗОБРАЖЕНЬ В РАДІОМЕТРИЧНИХ КОМПЛЕКСАХ

Використовуючи сучасні відомості про статистичний синтез радіометричних систем (РМС), синтезовано і досліджено алгоритм оптимального формування радіометричних зображень (РМЗ) за допомогою триантенних надширокосмугових (НШС) радіометричних комплексів. Знайдено аналітичний вираз для функції невизначеності (ФН) такої системи і приведено її моделювання для різних геометрій при використанні вузькосмугового, багатосмугового і НШС вхідного тракту. Показано, що перехід до обробки НШС і багатосмугових сигналів дозволяє сформувати ФН з однією головною пелюсткою, що виключає неоднозначність відновлення РМЗ.

***Ключові слова**: радіометрія, надширокосмуговий радіометричний комплекс.*

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SYNTHESIS OF OPTIMAL ESTIMATION ALGORITHM OF RADIOMETRIC IMAGES IN RADIOMETRIC COMPLEX

Using modern statistical information on the synthesis of radiometric systems (RMS), optimal algorithm for the formation of radiometric imaging (RMI) with the three-antenna ultra-wideband (UWB) radiometric system is synthesized and investigated. Analytical expression for the system ambiguity function (AF) is derived and examples of its simulation for different geometries is shown and the use of narrow-band, multi-band, UWB of the input path. It is shown that UWB and multiband signal processing allows to form AF with one main lobe.

***Keywords:** radiometry, ultra-wideband radiometric complex.*

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JUSTIFICATION OF REQUIREMENTS FOR A LONG-TERM GROUND AUTOMATED COMPLEX OF SPACECRAFT CONTROL IN GEOSTATIONARY ORBIT

In this article we present requirements for a long-term ground automated complex of spacecraft control in geostationary orbit, as a part of the methodology of enhancement of the functioning effectiveness of spacecraft control long-term systems.

Existing approaches to construction of a long-term ground automated complex of spacecraft control in geostationary orbit are normally based on the use of landing procedures under which parameters and management are optimized, provided the display is essentially characterized by one task (goal). Herewith the ideology of parametric synthesis with using of all traditional search methods of optimization is used. For example, under the existing approaches and the availability of favorable financing terms, the duration of the process of creating modern samples of space systems from concept to the first flight is at least 3-4 years, and under the development of fundamentally new concepts – is up to 7-10 years. In these circumstances, the price of possible research errors is naturally growing, which are practically impossible to fend off at the stage of systems application [1-2].

Current trends and features of the development of ground automated complexes of spacecraft control in geostationary orbit, as complex technical systems, are arising the requirements for quality and terms of their creation in terms of economy and resources. These requirements determine the urgency of developing the methodology of enhancement of the functioning effectiveness of spacecraft control long-term systems in geostationary orbit, under which to reach the required level of performance the best resources are used. Under the methodology, the authors mean set of principles, approaches, theoretical methods and techniques of research process improvement, implemented as a tested sequence of actions or operations (methods and techniques) to ensure the performance of conceptual synthesis [3] .

Formation and justification of the technical look of long-term ground automated complex of spacecraft control in geostationary orbit is the task of multicriteria parametric synthesis [2-4].

At the first stage of creating the adaptive ground automated complex of spacecraft control in geostationary orbit the designed object is described by a limited set of common parameters.

The system will be definitely determined by the set of parameters $y = \{y_j\}_{j=1}^{\alpha}$ which are optimized.

The analysis of projected conditions of creation and use of the system show the system of parametric restrictions on the numerical value of each characteristic in their entirety as:

$$\beta_{j_{\min}} \leq y_j \leq \beta_{j_{\max}}, j = \overline{1,\alpha}, \quad (1)$$

where $\beta_{j\min}, \beta_{j\max}$ – respectively permissible lower and upper limits of numerical values change , and y_j - –haracteristics. The quality system is evaluated by the set of partial conflicting criteria, which represent the functions of parameters and form a *m*-dimensional vector:

$$\varphi = \{\varphi_i(y)\}_{i=1}^{m}. \quad (2)$$

It is necessary to define such values of parameters $y^* = \{y^*{}_j\}_{j=1}^{\alpha}$ under which the vector of criteria is optimized (1) at known constraints (2).

Considering the process of spacecraft control in geostationary orbit as a sequence of two stages - –aking a decision and its implementation - –n accordance with the following it is necessary to define following modification levels of administrative decision: theoretically found and practically implemented. In relation to the first the concept of "q“ality" ”hould be applied and to the other – “efficiency”. Thus, the quality of administrative decision - –s the degree to which the parameters of the selected decision alternative meet a particular system of characteristics that satisfies an operator and allows the efficient implementation of the decision. Therefore, the general requirements should include: scientific validity; unity; timeliness; reality; adaptability.

The scientific validity of spacecraft control in geostationary orbit is primarily determined by the degree of consideration of space technology functioning and development, trends in the economy development and society as a whole. Therefore, the scientific validity of management depends on the competence of an expert who makes a decision at every level of management. An expert may be competent and make high-quality decisions and effectively implement it if only he has special knowledge. The decision will be competent if it adequately reflects the purpose and objectives of management based on knowledge of the real situation, with clear organization of the work of authorities, and also organization of the rapid restoration of broken administration.

The most common properties of scientific validity are: stability, manageability, observation, identification, complexity, decomposition.

Stability. The stability of the system refers to the ability to maintain its behavior at the output within certain limits at any time under small perturbations in the initial state and structure.

Manageability. The ability of system to pass from any initial state to the final state for limited time with acceptable impacts. Using the notion of manageability under the system analysis the question of scope will be pointed out, and under the synthesis - –he question of the fundamental structure and possible management restrictions.

Observation. System observation refers to the possibility of unambiguous determination of the condition and structure characteristics for a known signal at the output.

Identification. Identification refers to the opportunity to define the system structure for known signals at its input and output. If the system is identified, it is called closed, otherwise it is known as an open system [2,4].

Complexity. The concept of complexity is associated with many different conditions of the system and the indivisibility of its structure. If the system consists of *n* elements, we can consider the $n \times (n-1)$ connections between them.

Decomposition. The ability of the system to split into independent parts (subsystems). Decomposition property of some systems (assessment tasks) is closely related to the property of observation.

Besides, it should be noted that for ground automated complex of spacecraft control in geostationary orbit, as a technical system, apart from these properties there are such important performance properties as *reliability* and *efficiency*.

Analysis of processes that operate in the ground automated complex of spacecraft control in geostationary orbit shows two interconnected flows of signals: control signals flow and information flow. Control Flow is used to provide the desired purpose of system functioning. The information flow is used to develop the necessary control signals. Control Flow is related to optimization problem of system structure and condition of the system. Information flow is related to the problem of evaluation of the system condition and structure characteristics (with known structure). The interrelation of above entered concepts should be provided in a logical diagram (Fig. 1).

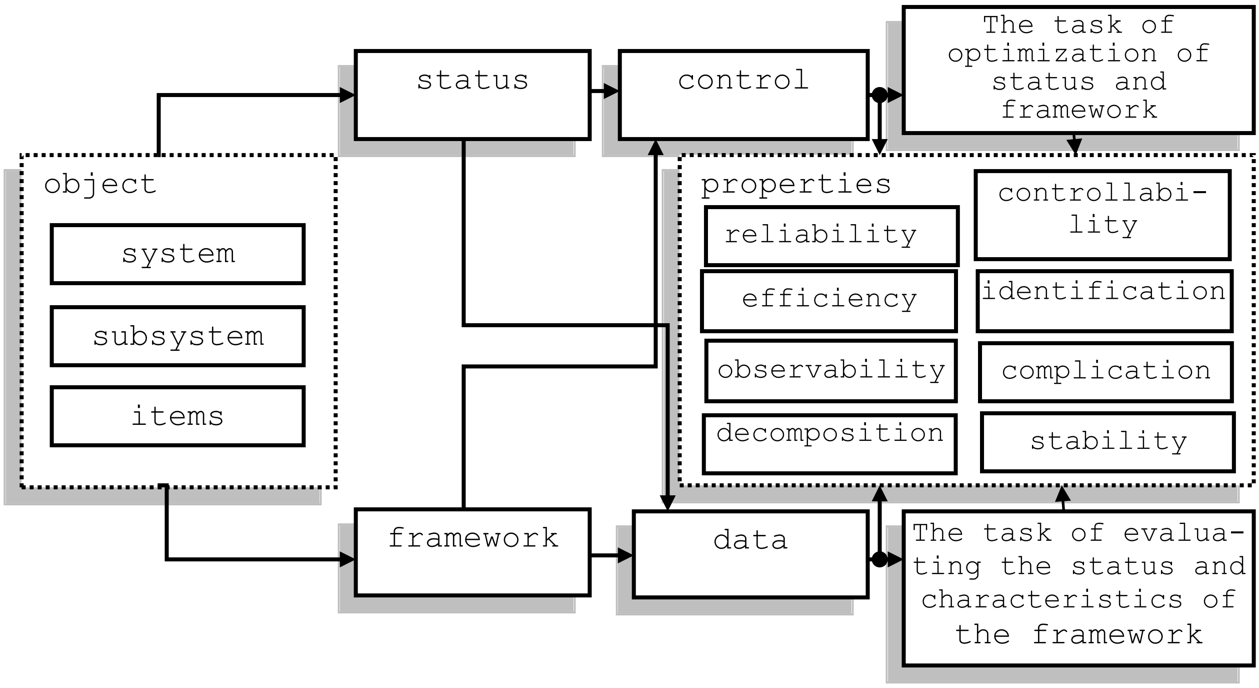

Fig. 1. Logic circuit interconnection properties of scientific validity

Unity. Unity of spacecraft control in geostationary orbit can not be achieved except through a sequence of complementary, consistent partial solutions which have organizationally purposeful, motivating, controlling and regulating nature.

Timeliness. The quality of the decision made on spacecraft in geostationary orbit in terms of real time is determined by its timeliness.

Reality. Decisions should be made and accepted considering the objective possibilities of space and ground segment.

Thus, spacecraft control in geostationary orbit can be considered high-qualified if it meets all the requirements listed above. Herewith we are talking about the conditions of the system since the failure of at least one of them leads to defects in quality and therefore the loss of efficiency, or even impossibility of its implementation.

Adaptability. Factor of changing impacts on the process of spacecraft control in geostationary orbit, dictates the necessity to perform another condition - –daptability.

As it is known, the process of synthesis of system control always provides for, firstly, precisely articulated management goals, and secondly, the availability of a priori information about the management object and the nature of perturbation acting on it. The volume of a priori information may be different. However, in this case the principal one is the question of sufficiency or insufficiency of a priori information about the object for achievement of the articulated management goals.

Management systems, built by using a priori information, sufficient to achieve the goal of management, are related to non-adaptive, regardless of the implemented management principle, the presence of feedback, randomness or determination of perturbations, used computational tools, etc. If the volume of a priori information about object properties can not achieve the articulated control goals, then the focus should be on adaptive control system. Thus, the adaptive control systems should include only such systems, which are designed for operation under a priori uncertainty and which in the operation process automatically adapt to random changes in the properties of the object and the environment.

According to the level of formalization of a priori uncertainty known approaches to building adaptive systems are divided into: parametric adaptation under which a priori uncertainty is the lack of knowledge of the parameters of the managing object, non-parametric adaptation, under which a priori uncertainty is not directly related to any parameters.

In both cases, uncertainty is reduced on the basis of successive observations of input and output signals in the management process. The objectives of spacecraft in geostationary orbit in terms of setting are closer related to the objectives of parametric adaptation.

According to the organization of process adaptation the used methods are divided into: searching, which are characterized by an iterative process of movement to achieve the required quality control; non-searching, based on the use of some necessary (sufficient) conditions of the required quality control.

According to the purposes of organization adaptations can be distinguished as: systems with special properties, operation of which makes the management process take some required properties, which may include stability, sensitivity to any perturbation or a priori information errors, etc.; optimal systems which ensure minimization of some functionals, reflecting the quality of controlled movement.

The use of non-searching systems with parametric adaptation seems to be more perspective for the flight control of spacecraft in geostationary orbit. These systems allow the maximum use of a priori information about the structure and parameters of the spacecraft.

The most developed type of adaptive control systems are obviously adaptive optimal control systems that combine high adaptation to the operation conditions with the movement control optimization and energy consumption for management with the chosen criterion of quality.

Implementation of adaptive optimal control of spacecraft flight will provide an opportunity to successfully solve the problem of creating a new generation of ground automated control system spacecraft due to: a significant expansion of the range of conditions in the use of different types of spacecraft; provision of comprehensive optimization of system functions performance; increase of safety of the spacecraft flight, including boundary modes (near border areas of operational modes); decrease in time and resource spending for development and operation of certain elements of the system due to the high level of unification.

Among the current approaches to building adaptive spacecraft control systems in geostationary orbit, there are various theoretical premises and techniques. The analysis of publications [1,2,4,5] allows to draw conclusions about the current state and the construction of adaptive spacecraft flight control systems.

Conclusions. Firstly, the concept of building adaptive spacecraft flight control systems in geostationary orbit based on combination of identification process parameters, evaluation of the state and optimization of a control signal are dominant. Secondly, the most common at this time is the identification of the selected model parameters of spacecraft movement with the help of algorithms that implement the method of least squares. Thirdly, the creation of spacecraft control laws one can observe using analytical relations of the real process and its reference models, analytical use of regulators that allows to determine linear feedback for the line facilities, optimal in the sense of quadratic criteria.

Noteworthy is the idea of combination of different principles of automatic configuration management systems. Thus, the unification of a setting by the parameters of the environment parameter adaptation [4-7] allows to take advantage of these approaches without the defects inherent to each of them separately. Software configuration by environment settings will provide a high speed device control system until the changes in the state and compensate emerging issues of sustainability.

Thus, nowadays the use of adaptive spacecraft control systems in geostationary orbit seems to be quite perspective. Research in this area, being developed in different countries, include sufficiently large number of approaches to the construction of such adaptive systems. However, in general, the problem of adaptive spacecraft control in geostationary orbit is far from comprehensive solution and that determines the relevance of research in this area.

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