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The communication system functional stability with critical objects

Annotation: One of the requirements for complex technical systems is stability, a probabilistic characteristic of the system that determines the system ability to fulfill its purpose. The article deals with the problem of ensuring the communication system functional system with critical objects, determined through the ability of the system to perform its functions. To ensure functional stability, it is proposed to consider the process of managing the system resources on the basis of monitoring and control data.

Keywords: critical object, communication system, control system, the communication system functions and tasks, functional stability

Modern technical control systems include a communication system that ensures the delivery of commands that characterize the control action. The communication system, like the control system, is a complex functional-dynamic and organizational-technical multi-object hierarchical system distributed in space. Complex technical systems are subject to stringent requirements.

One of the most important requirements for any such systems is stability. In accordance with GOST [1], stability is considered through reliability, survivability. Stability can be viewed as a requirement for a system with a certain indicator, or as a property of the system that determines the constancy of the structure, behavior of the system and the processes occurring in it. Russian mathematician A.M. Lyapunov gave a definition of a complex system stability, which means the ability of the system to function in states close to equilibrium, under conditions of constant external and internal disturbing influences [2].

In [2], the key concept of determining the stability of the system functioning is structural and functional stability. Under the influence of various factors, the system constantly undergoes changes in state, and the measure that allows you to determine the influence of these changes on it is the set of functions it performs.

In the works of V.V. Lipaeva, M.G. Kuznetsova, E.S. Gorbachik [2] and other scientists, stability was considered as a probabilistic value that characterizes the change in the standard state of the system under the action of clearly defined influences. The stability of the system functioning must be considered from the side of functioning process in conditions of uncertainty of various factors influence with the possibility of predicting the system state at the moment of the influence beginning, during the process of influence and at the moment of such influence termination.

What does the system functioning mean? The system functioning is understood as a complex process of performing its functions by the system [3]. The stability of the network functioning is defined as its ability to perform its functions in the event of some of the elements failure [1]. The functional stability of a communication system does not always imply finding an equilibrium state of the system and maintaining it, while the presence of critically important objects (CIO) determines the lack of equilibrium. The functional stability of the communication system with the CIO is the ability of the system in conditions of important objects criticality to perform its functions and tasks that allow achieving the goal of the system's functioning under the influence of various destabilizing factors.

The criticality of a communication system object is its property, which characterizes the impact of a violation (termination) of its functioning on the functioning of the system, the fulfillment by it or its elements of goals, functions, tasks.

A distinction should be made between static and dynamic criticality. Static criticality is a property of the system element, itself, which does not change over time. Dynamic criticality characterizes a property, which is determined by the conditions of its functioning in time.

Functional stability, as a scientific direction, has been developed with the emergence of complex technical systems, primarily in the aviation, space, rocket and navigation areas. The reservation of system individual elements, the use of additional control systems did not give a significant result and did not in any way affect the likelihood of failure of the system elements, but only complicated the system and gave an additional load on it. In addition, the additional load in the form of new elements and new tasks requires large material costs.

The main idea of ensuring the functional stability of a complex functional-dynamic and organizational-technical system is resource management, in the event of (prerequisites for) conflict situations in the system, to ensure the performance of its functions and purpose.

In works [4], the fundamental condition for ensuring functional stability in problems of managing complex autonomous objects is the possibility of redistributing available resources within the system. Abnormal system conditions,

In work [4], the fundamental condition for ensuring functional stability in problems of managing complex autonomous objects is the possibility of redistributing available resources within the system. Abnormal states of the system caused by failures were considered as admissible, functionally stable management of them is aimed at eliminating the consequences of failures and ensuring the performance of system functions.

The technological basis for ensuring the functional stability of complex systems is the creation of information and control complexes [4] and decision support systems that allow concentrating information about the state of the system, the processes occurring in it and the provision of their resources. It should be borne in mind that to ensure the functional stability of the system, it is necessary to combine all monitoring and control systems of various systems and elements of a complex system as part of a single information and control complex, to ensure their interface and interaction.

To ensure the functional stability of the communication system with the CIO, it is necessary to determine the target purpose of the system, the conditions for ensuring its functional stability.

The target purpose of the communication system with the CIO will be as follows:

$$f(y,d,u,v) \in Q, \qquad f^*(y^*,d,u,v^*) \in Q \tag{1}$$

where f – is some operator defined on the set $(y,d,u,v) \in Z$, $y(x,t) \in \mathrm{Y}$ – is the set of communication system tasks, the execution of which over time is provided by the corresponding set of resources $x \in X$, $d \in D$ – is the set of internal and external influences that disrupt the functioning of the system, $u \in U$ – is the set of control actions of the system that ensure functional stability, $v \in V$ — is the set of objects of the system, the * sign determines belonging to the CIO, Q — is the permissible range of values of the function f characterizing the functioning of the system, that is, the fulfillment of its intended purpose.

Conditions for ensuring functional stability

$$\forall v \in V, v^* \in V, d \in D, y(x,t) \in Y \exists x \in X, u \in U: f(y,d,u,v) \in Q. \tag{2}$$

To describe the communication system, consider the graph $P_v = \{V,\ S\}$, where V – is the set of graph vertices characterizing the system elements, S – is the set of graph arcs characterizing the connections between the communication system elements. A functional-dynamic complex system will be functionally stable if, in the event of a malfunction of any element, there is at least one path that allows it to move from one vertex to another. The ability to perform functions by the system is determined by the graph $P_f = \{Y, X\}$, where Y – is the set of graph vertices that characterize the system's performance of tasks, functions, and goals, X – is the set of arcs that characterize the resource required to complete the task, function, goal.

The representation of the system in the form of graphs allows for a quantitative assessment of the system functional stability.

Ensuring the functional stability (2) of the communication system under conditions of functioning uncertainty and the impact of various destabilizing factors is an important technical problem and needs to be addressed.

The use of graph theory and matrix theory allows one to quantify the functional stability of a system for simple systems. For systems with a hierarchical structure, it is necessary to separate the elements according to their influence on the functioning of the system.

When considering functional stability, it is necessary not only to determine the presence of a failure and to counteract it, but also to predict the state of the system in the future, which implies the intellectualization of the system of government by complex functional dynamic systems.

To ensure functional stability and ensure the system resources management, it is necessary to concentrate complete information about the system state, its resources at anytime from all sensors, monitoring and control systems [5].

Modern methods and techniques for assessing the stability of functioning do not take into account the process dynamics of system functioning and the state uncertainty. The functioning process of the communication system must be represented in the form of a set of tasks – regulations determined by the resource and time required for their implementation [6,7].

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Кереселидзе Н.Г.

Новые модели распространения вируса SARS-CoV-2 и проблемы управления безопасностью

Аннотация: Предложена новая математическая и компьютерная модель распространения вируса SARS-CoV-2 с учетом протокола борьбы с эпидемией принятой властями Грузии. Ставится задача управления борьбы с эпидемией при вакцинации с временным иммунитетом.

Ключевые слова: математическая, компьютерная модель, SARS-Cov-2, управление, эпидемия

1. Введение

Моделирование процессов пандемии COVID19, вызванной вирусом SARS-CoV-2 представляет повышенный интерес. И это естественно, пандемия унесла немало жизней, увеличило число людей с различными заболеваниями, ухудшило благосостояние