

Controlling the operation of the intelligent generator and energy translator integrated from space and planetary objects as the elements of a power plants in space (in orbit)

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Abstract. The author analyzes problems of using artificial intelligence based of monitoring systems and management, as well as the opportunities of operating performance parameters of networks transporting energy resources within a quasi-integrated electric power super-system of the gigawatt level, the space part of which consists of distributed satellite formations as quasi-integrated segments of orbital power stations. In this case, you must consider the increasing presence of intelligent control devices (e.g., cyber-physical device conversion and switching energy, intelligent management system, open service platform, etc.). The author offers to predict the dynamic characteristics of the integrated quasi-integrated electric power super-system when analyzing the interrelations of metastable states in the processes of obtaining energy from objects of space power generation in the microwave, laser or other mode and converting it into electric power by ground installations.

1. Introduction

In the last two decades, a new effective tool – the theory of complex networks-has been developed to study the problems of functioning of complex systems. Network nodes are considered as elements of these complex network systems, and the links between these nodes are considered as interaction between elements [1].

Projects of the removal of primary sources of energy generation from the Earth's surface into outer space make it extremely important to integrate space and ground-based power generation and transmission systems within a quasi-integrated electric power super-system of a gigawatt level, the space part of which consists of distributed satellite formations as quasi-integrated orbital segments power plants [2-5]. The block diagram of information integration of space and ground power generation and transmission systems within a quasi-unified electric power super-system is shown in Figure 1.



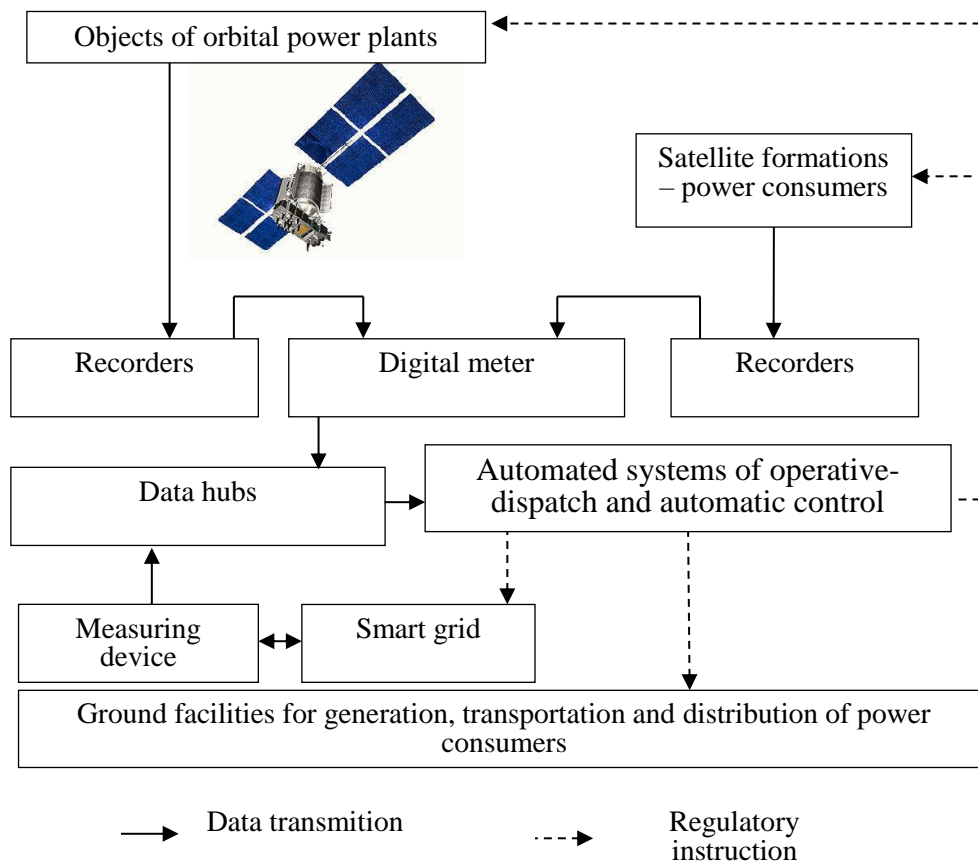


Figure 1. The block diagram of information integration of space and ground power generation and transmission systems within a quasi-integrated electric power super-system.

2. Statement problem

The complexity of the solution to this problem lies in its versatility, since the disconnection of only a few lines can divide a single system of transportation of any kind of TER into separate isolated areas. Given the uneven distribution of generating capacity and the considerable distances to which electricity is transferred, as has been the case in our country, new concepts must be developed using modern technological advances. Including with a focus on overcoming the existing barriers (technical, departmental, etc.) for effective joint work of various structures of organizational, technological, etc. management related to the work of energy infrastructure systems of Russia [6].

The authors propose to rely on the controlled fragmentation of the quasi-integrated electric power super-system in the framework of technologically and organizationally structured energy clusters (by analogy with temporary functional neural clusters), followed by the restoration of the system integrity of the energy supply of consumers and the transit transportation of energy resources.

High-latitude energy reception when using the microwave range of wavelengths is difficult in high-latitude regions of the Earth, where the main energy consumers of Russia are located, but may be of commercial interest for power supply to Canada, Greenland and other high-latitude islands of the Northern Hemisphere, Antarctica, and also Antarctica. In the laser concept, this problem is easily solved in Russia.

3. Methods

It is planned to develop a subject-adapted configuration of the basic characteristics of the complex of monitoring and control systems, including the possibility of operating the operating parameters of the networks transporting energy resources, within the quasi-integrated electric power super-system. It is

necessary to identify system-parametric relationships (relations), including the amount of electricity flows and its consumption in the areas of the quasi-integrated electric power super-system, formed by the results of the monitoring stage and the initial situation analysis of the studied object (network segment).

This requires the development of a set of tests in predicting outcomes of natural and technogenic nature on the basis of retrospective analysis and forecasting of the magnitude of flows of electricity and its consumption in areas of energy of the super-system. The test results should provide an opportunity to increase the survivability of the systems of transportation of energy resources (electric power networks, etc.) in the conditions of probable critically fast cascade development of the effect of damage from the avalanche - like distribution of overload that occurred in one of the nodes of this network and an acute shortage of resources to maintain the normal operation of the object (network segment).

If, as a result of natural or man-made phenomena, the nodes in one of the segments of these networks fail, this can cause failure of the nodes in the other segment of the network, and this will lead to iterative cascade damage to the nodes in both segments of the network. The criteria of survivability should be focused on the energy cluster as a functionally stable element of the spatial organization of the quasi-integrated electric power super-system, which allows to preserve the possibility of energy supply to consumers in the conditions of the probable collapse of the system due to natural or man-made phenomena.

A set of convergent information, telemetric, analytical services allows to rely on the model of self-organization and decay of functional neural network structures and defines a set of dynamic patterns. These patterns in the field of cascade processes, where initiated due to natural or man-made phenomena cascade process can be completed or continue, depending on the heterogeneity of the parameters of the state and mode of the network, are sub - patterns corresponding to this target block neural networks pattern and their analogues in the model - parallel operation of many nodes and the ability of the network to change its configuration-contribute to the high reliability of such a network structure, depending on the heterogeneity of the parameters of its state. System-parametric relationships allow us to calculate the "convolution" of energy consumers and energy networks within clusters and the breakdown of the fuel-energy super system in such a way that each energy cluster is represented as a kind of one aggregate energy consumer, strongly or weakly connected with other energy clusters that support the energy supply of consumers.

In accordance with the proposed technology, information and computing "convolutions" of energy consumers and energy networks within clusters, implemented as a set of intelligent information and computing services, are presented in the system under consideration for analysis and decision-making in the interests of controlled fragmentation of the quasi-integrated electric power super-system within technologically and organizationally structured energy clusters (by analogy with the dynamic core - functional cluster of neurons) with the subsequent restoration of the system integrity of energy supply to consumers and transit transportation of energy resources. These solutions are dynamically adapted to the individualized profile of the system of continuous assessment of the state of TER transport systems on the basis of the system of monitoring of transitional regimes taking into account the forecast of the need to maintain a balance between generation and consumption (by analogy with the synchronization of brain cell ensembles during changing neural interaction) both in normal and emergency conditions to counteract the cascade development of the effect of damage from natural or man-made phenomena.

The monitoring allows to identify compliance of the subject-adapted configuration of the basic characteristics of the possibility of operating the operating parameters of the networks transporting energy resources, within the quasi-integrated electric power super-system, depending on the damage from natural or man-made phenomena by self-diagnosis of individual objects, network segments and the entire system (by analogy with distributed neural circuits) and the restoration of power supply to consumers.

The package of methods for monitoring the TER transportation systems as a kind of giant interconnected clusters of network nodes in respect of the avalanche-like propagation of the overload that has arisen in one of the nodes of this network includes dynamic patterns in the field of cascade processes, where the cascade process initiated due to natural or man-made phenomena can be completed or continue, depending on the heterogeneity of the parameters of the state and mode of the network.

Monitoring services should allow using application software packages to simulate the forecast of situation development with a focus on maintaining the relationship of all the components of the controlled energy cluster, part of all sources of generation, loads, elements of the topology of the backbone networks for energy carriers in the context with the lowest possible levels of energy consumption in the framework of increasing the survivability of systems of transportation of energy resources (electricity networks, the etc.).

This package of methods for monitoring the segments of energy resources transportation systems provides for the possibility of supporting the necessary activity of each energy cluster as a fractal part of the quasi-integrated electric power super-system in the performance of power supply functions within the criteria for maintaining the necessary activity of life support systems and state management institutions.

4. Discussion

In the considered system for the analysis and decision-making in the interests of controlled fragmentation of the entire quasi-integrated electric power super-system within the framework of technologically and organizationally structured energy clusters (by analogy with temporary functional neural clusters), followed by the restoration of the system integrity of energy supply to consumers and transit transportation of energy resources can be implemented to identify the system-parametric relationships of various aspects of the functioning of infrastructure facilities from the standpoint of the model of self-organization and collapse functional neural network structures.

From the point of view of ensuring effective functioning, the architecture of of the intelligent generator and energy translator based:

1) The monitoring subsystem of the measured parameters of various physical fields, environments and objects that ensure the formation of the current observed state of a swarm of space objects, modules ("boards"), including situational awareness is provided either through direct on-board interaction between modules, or by transmitting "on board" each module of information from a ground-based surveillance system.

2) The subsystem of diagnostics of anomalies of controlled processes, which, on the basis of data from the monitoring system, will identify the cause of the anomaly and determine the current state of the controlled objects to control the complex of modules ("boards").

3) The subsystem for analyzing current characteristics, which, based on information obtained from the subsystem for diagnosing anomalies of controlled processes, evaluates the functional capabilities of stabilizing controlled objects in a changed situation, including the possibility of adding or excluding any number of elements [modules ("boards") or computing nodes] from the network (cloud, swarm).

4) The evaluation subsystem of the current management plan for telematic, computing and information services, which analyzes the impact of the degradation of the functional characteristics of the control systems on the attainability of the current goal and, in case of unsuitability of a given plan, gives a corresponding warning.

5) Intellectual agent, which realizes the re-planning or adjustment of the algorithms of the telematics, computing and information systems by using not just logical algorithms, but more complex intelligent algorithms of neuro-fuzzy control.

The application part should include the following basic modules:

- a real-time monitoring system for the development of violations in time and the distribution of violations by interacting subsystems in a convergent information and computing platform for managing a set of modules ("boards");

- an intelligent real-time agent to adjust the control of the movement of modules (“boards”) and optimize solutions based on planning machines for operational control;
- an interface for issuing recommendations to modules (“boards”) for stabilizing the process of managing a complex of modules (“boards”) in a critical situation;
- real-time solver for issuing recommendations to modules (“boards”): issuing recommendations for applying control actions in a given current situation;
- subsystem display the current situation in a converged information and computing platform based on the dynamic pool of functional network structures is provided to support the necessary activity of each energy cluster as a fractal part of the quasi-integrated electric power super-system;
- user interfaces in a convergent information and computing platform for managing a set of modules (“boards”).

It is expected that the use of elements of artificial intelligence allows to approach the optimal limiting values of the parameters of normal and critical situations in real time in such a way that will allow one to come closer to the margin of the limiting values of the parameters of the controlled space objects due to the increased possibilities of observation and control.

At the same time, each module (“board”) can be not only a source and a recipient of information, but also a relay router, and the node (cluster) of modules becomes a computing node as part of a convergent information and computing platform simultaneously forming a network interaction driver other functional network structures is provided to support the necessary activity of each energy cluster as a fractal part of the quasi-integrated electric power super-system.

In the implementation of the considered approach is required to determine the direction of regulation of the controlled elements of the energy cluster, part in respect of all sources of generation, loads, elements of the topology of the backbone networks for energy carriers in the context with the lowest possible levels of energy consumption with the goal of creating dynamically configurable structures survivability systems transportation energy resources (electricity networks, etc.).

Restrictions on the transfer of energy from orbit to earth in many regions of Russia make this situation almost inevitable.

5. Conclusions

The connection of each of the above iterations in the area of complex phase spaces, where the initiated peak of the maximum load passage in power systems can be completed or continued, depending on the heterogeneity of their state parameters, including the linear or non-linear component, which varies in time, allows complex analysis to highlight information about the causes of significant dynamic disturbances in the studied electric power super-system and the occurrence of feedback [5; 6].

On this basis, it is possible to determine the state of self-balancing of the integrated electric power super-system and the dynamics of operation of the component power systems taking into account the possibility of forming synchronous groups in conditions of non-guaranteed use of the power of space energy sources during the period of maximum consumption in a specific ground-based territorial segment.

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