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Algorithms of Determining the Optimal Structure of a Telecommunication`S Power Supply System Based on Morphological Synthesis

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Abstract: It is necessary to develop design principles and methods based on morphological synthesis and analysis of technical solutions to solve the problem of optimal design of power supply systems for a telecommunications power supply system. The essence of the morphological method is that it is necessary to determine several morphological features that are important for the problem being solved, and to make all possible combinations of these features. Its advantage over other methods is that it is possible to analyze the functional characteristics of the power supply system, its actions in a dynamic mode under the influence of changes in the network, load and change the mode of the operation. This article studys the optimal structure of the telecommunications power supply system.

Keywords: power supply system, electricity production, transformation, transmission, distribution and consumption, combinatorial-logical synthesis, morphological synthesis.

I. INTRODUCTION

In the creation of complex technical systems, several stages of synthesis are passed, which are, structural, functional and parametric stages. In the field of scientific research, there are no methods that allow immediate selection of the optimal structure of a complex system or device based on any criteria. Therefore, the process of creating complex technical systems is repeated [10-12].

First, it determines which class the simulated device belongs to, then narrows the boundaries of this class, tests several solutions related to this class, and selects the most suitable one. Currently, computer components are widely used to support decisions at the initial stages of designing technical facilities. [6].

The essence of the morphological method is that it is necessary to determine several morphological features and to compile all possible combinations of these features. Technical systems that are being improved have several structural or functional morphological features, for example, each feature is related to some structural unit of the system. The advantage of the morphological method is its wide range of possibilities in formalization, algorithmization and computer implementation. To create a system, included devices in this set should be described, the classification properties and the range of their possible values should be determined. A special feature of this classification is that we can determine the structure of the device by specifying all the values of the classification properties. Morphological synthesis belongs to the class of combinatorial-logical synthesis methods, and one of its disadvantages is that it is a complex process to implement on a computer, taking into account the complete enumeration of possible options. In addition, the existing universal

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algorithms do not guarantee to determine and synthesize the desired result in a short time. Recently, genetic algorithms simulating evolutionary processes are being frequently used in morphological synthesis.

II. SETTING OF THE PROBLEM

Since any device or system has a structure and its constituent elements have parameters, structural-parametric synthesis methods can be used in almost all areas of scientific and technical knowledge. Therefore, in this dissertation work, it is proposed to develop the theory of morphological synthesis, which includes the structures and individual devices of the power supply system (PSS), which are part of the morphological set, and the models of PSS. To implement the morphological method, it is necessary to supplement the morphological set with methods of mathematical modeling of the considered objects, as well as with engineering calculations and obtained knowledge during their operation. It should be noted that morphological methods are the basis for modeling complex technical systems. Therefore, the principles of optimal PSS design for telecommunication systems are a combination of morphological methods, mathematical modeling methods and engineering developments. The macro model of the power supply system, is a model of devices of several classes, which select these devices according to certain criteria (low level of conductive interference, reliability, quality of energy conversion, high energy efficiency sensors, minimum body cost, etc.) are complemented by synthesis methods and algorithms with optimization [8].

III. METHODS

Morphological set includes all structure of PSS (for example, centralized or decentralized). There are various schematic and technical solutions, which differ in the parameters of the system objects under consideration, the morphological set of individual elements. For example, rectifiers can be implemented with or without a transformerless input circuit using a power factor rectifier (PFC) circuit. Morphological set elements differ in system structure and parameters (transformers, filtering devices, etc.). Such sets can be unordered or partially ordered [12].

To represent a set of PSSs using a morphological tree, it is necessary to arrange the elements of the set. Despite the fact that the classification features are the same, the morphological set of features of power supply systems and devices of telecommunication systems can be classified in different ways.

By defining the classification features and bringing them into a single system, we get a set that represents the model of the morphological set at the level of identification. We call this as model of the studied power supply system M1 macromodel (Fig. 1). It can be represented as a morphological tree or a morphological table. The representation of the morphological set in one form or another is represented by mathematical models (in the form of systems of equations) [6].

A multi-level model of the power supply system.

Modeling process of the systematization of the power supply system consists of dividing a complex nonlinear system into a number of subsystems and creating a five-level hierarchical structure - M1 macro model (Fig. 1).

To create a morphological analysis algorithm and present its results in the form of the M1 macro model, we divide subsystems into main and subclasses according to its architecture and accepted classification features. The main class, which includes the macro model of the power supply system, can be divided into subclasses taking into account their functional aspects.

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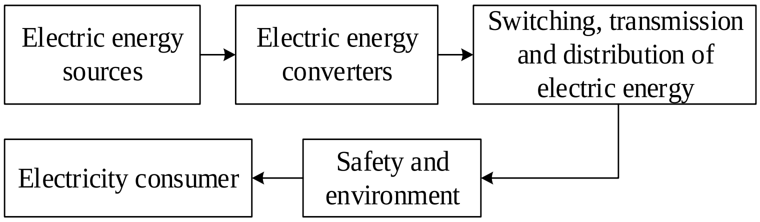

Figure 1. Five-level hierarchical structure of the power supply system (M1 macro model)

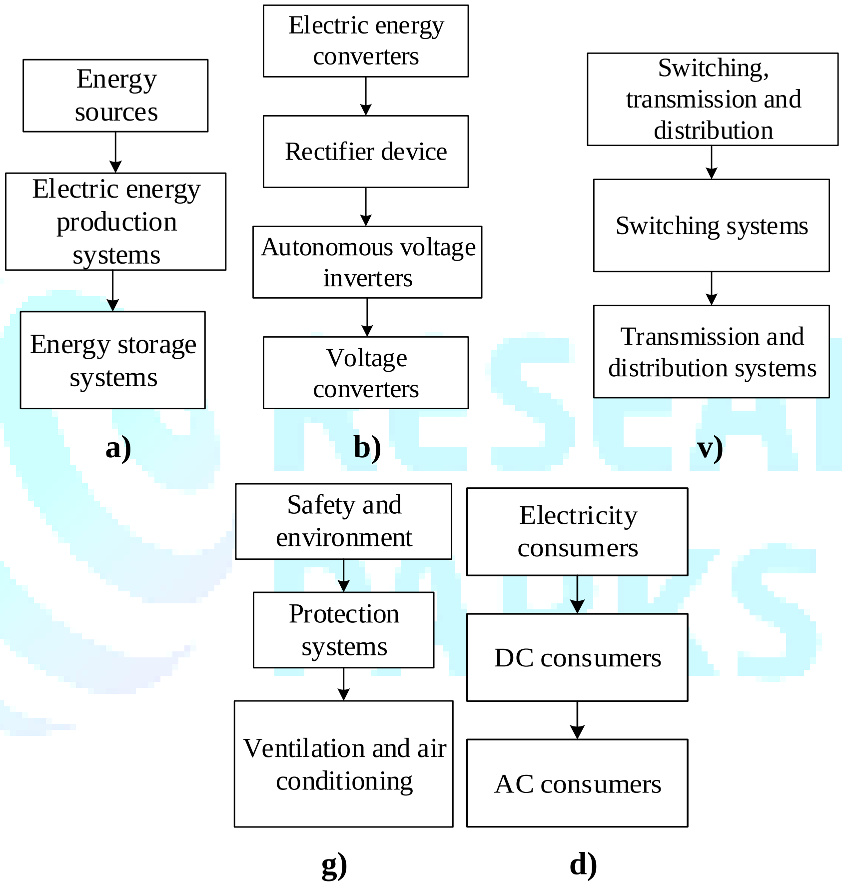

Figure 2. The hierarchical structure of the five-level M1 macromodel power supply system.

To ensure the normal operation of the equipment of the industrial facility, the power supply system must perform the following functions:

- electromagnetic compatibility (EMC) requirements, including transmission of quality electricity from a source to a specific consumer; ensuring electrical safety of employees and protecting equipment from external influences;
- ensuring the specified state of the air environment for the normal operation of equipment and the life of service personnel.

In terms of performing these functions, the power supply system can be represented as a macro model consisting of five blocks (hierarchical levels) shown in Figure 1. The model includes the following blocks

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(subsystems):

- ✓ block of electrical energy sources;
- ✓ unit for converting one type of energy into another type of energy;
- ✓ other subsystems, as well as power transmission and distribution networks, a block of switching devices;
- ✓ block of protection, ventilation and air conditioning systems;
- ✓ a block of consumers with different parameters and requirements for the EMC of the equipment of the industrial facility, the quality of electricity.

When further decomposing the M1 macromodel and analyzing the subsystems, we take into account the functional nature of their classification (Figure 2).

In the further analysis of the decomposition of the blocks included in the subsystems, the structural and parametric features of the classification are taken into account. To solve the problem of synthesis with optimization according to any criteria, we set priorities between classification features and block parameters, taking into account the suitability of the parameters of individual elements of the PSS (Fig. 3, 4, 5, 6).

The main functional task of the power supply system is to change, control, distribute and continuously supply electricity from the source to the consumer with constant and variable voltages [11]. Modern industrial equipment includes a set of devices with information systems and a complex infrastructure, which requires PSS manufacturers to take a comprehensive approach to creating an optimal system of industrial equipment and PSS systems working together. In the process of creating such an optimal power supply system, it is necessary to ensure the quality of power conversion, EMC with industrial facilities, reliability of power supply, safety for people and the environment.

In addition to general system requirements for power supply systems, there are also requirements defined by regulatory and technical documents. Macromodel M2 consists of five hierarchical levels, and the first level contains sources of electric power, power generation and storage systems (Fig. 3).

The Republic of Uzbekistan has developed and is implementing the state standard UzDSt3055:2016 “Telecommunications networks. Organizational ATS. General technical requirements and methods of control”. In accordance with this standard, general power supply and redundancy systems provide telecommunications devices with three-phase or single-phase alternating current with a frequency of 50 Hz and a rated voltage of 220/380 V [1-2-3-4].

In order to meet the main requirement for the reliability of power supply of telecommunication equipment and guaranteed power supply, it is necessary to ensure that the power supply system has at least two inputs from independent energy sources and includes an internal power plan (U11i, U12j).

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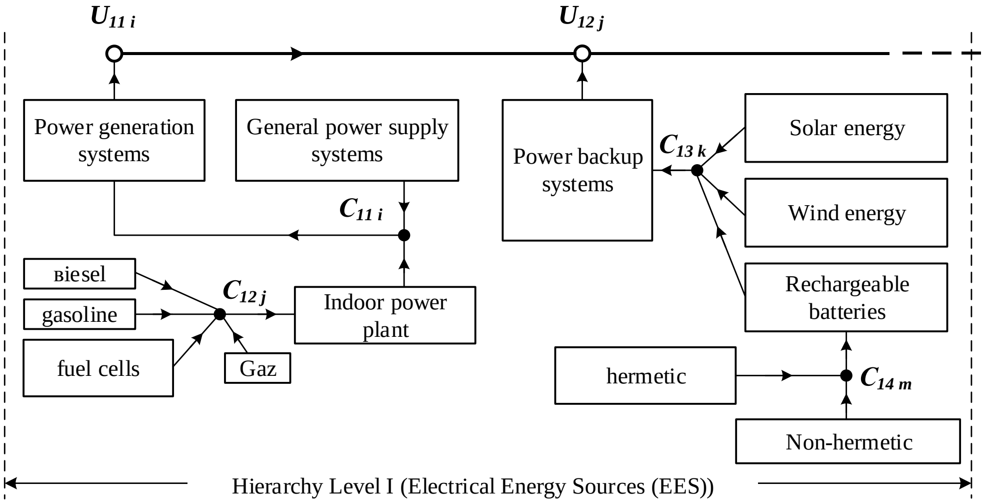

Figure 3. Level I of the hierarchy.

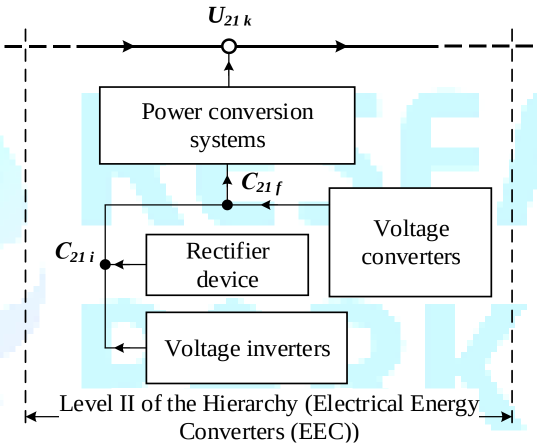

Figure 4. Level II of the hierarchy.

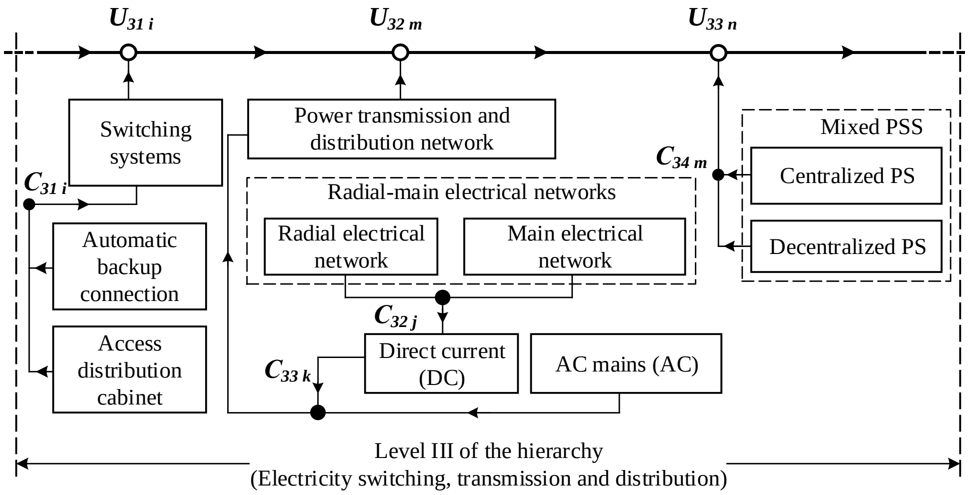

Figure 5. Level III of the hierarchy

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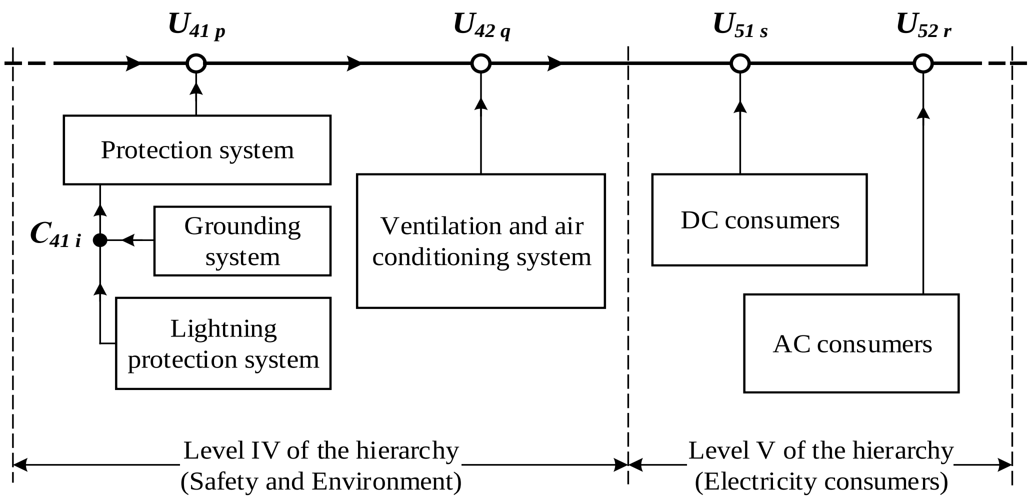

Figure 6. Level IV and V of the hierarchy.

IV. RESULTS

Based on these requirements, electricity generation (U_{11i}) occupies the first place in the hierarchy of energy resources subsystem.

In the second hierarchical level of the M2 macro model, there are energy converters (U_{21k}) containing three hierarchical levels, which are rectifier, voltage inverter and voltage converter (Fig. 4). The conversion of the necessary electrical energy for electrical devices must be efficient.

The third hierarchical level of the M2 macro model contains switching, transmission and distribution systems of electric energy, which includes two hierarchical levels (U_{31i}, U_{31m}), consisting of the switching system (SS), transmission and distribution networks (Fig. 5). SS is located at the top of the hierarchy of the sub-system of switching, transmission and distribution of electric energy. SS is designed to switch from one operating mode of the power supply system to another, and one of the requirements for it is to provide uninterrupted power supply to consumers and protect against short circuits that occur on the load side.

The fourth hierarchical level of the M2 macro model is the safety and environmental system (U_{41p}, U_{42q}), which includes two layers, i.e. protection ($U_{41\mathrm{p}}$ p), ventilation and air conditioning (U_{42q}). Shown on (Fig. 6).

At the fifth hierarchical level of the M2 macro model are electricity consumers (U_{51sp}, U_{52r}), according to consumer requirements, they are direct (U_{51sp}) and alternating current (U_{52r} r) consumers (Fig. 6).

The developed M2 garf model includes a five-level M1 macromodel. Macromodel M1 has the form of a tree with logical “AND” and “OR” logical nodes, where Sij is a constant coefficient for evaluating options according to the specified criteria of its attached elements for choosing alternative solutions at one level, Ukm is a graph of macromodel M1 option valuation coefficients. In order to create a continuous connection between the nodes in the graph (if the system has not passed through the sheep system), a single connection coefficient was introduced, which allows to create continuity along the graph while preserving the parameters. For example, while using a hermetic, it is not always necessary to install a ventilation and air conditioning system.

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V. CONCLUSION

1. The analysis of the modeling methods showed that the morphological analysis and synthesis method is the most suitable method in the hierarchical trees of the power supply system. Its advantage over other methods is that, it is possible to analyze the functional characteristics of the power supply system, its dynamic behavior under the influence of changes in the network and the change in the operating mode.
2. It is the most optimal modeling package for creating automated design systems of the power supply system for the best indicators of power quality, as well as for establishing relationships between elements at different hierarchical levels, both linear and non-linear.
3. Systematic approach to the analysis of power supply systems is the formation of an orderly set of the hierarchy of classification characteristics of the sub-systems that are part of it, the creation of morphological trees and subgraphs that will be part of the macromodel M1 in the future, the formation of symbolic-numerical relations between the nodes of the macromodel tree in the form of matrices allows.
4. According to the classification characteristics of the elements of the five levels of the M1 model, followings were created after processing the data obtained during the systematic analysis of the power supply system of the telecommunications facility:

1) subgraphs of all levels of macro model M1, their adjacency and incident matrices;
2) M2 model and morphological set of elements.

To create the M3 model, it is necessary to create equations describing the obtained subgraphs, create a database containing external and internal parameters. Moreover, the problem of synthesizing the optimal power supply system through their controlled parameters is solved.

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