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FEATURES CALCULATIONS OF DYNAMIC MODES OF THE ELECTRICAL SYSTEM

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Annotation. *The purpose of the study is to consider modeling the modes of local objects on a single information model within the framework of an automated system for controlling the modes of electrical systems. A mathematical model of the electrical system is proposed, based not on a general system of equations for the entire system as a whole, but on a set of subsystem elements: generators, load nodes, network, for which systems of equations are considered. This will allow expanding the range of tasks to be solved, which relate to the tasks of operational emergency control.*

Keywords: *network, load node, generation node.*

As is known, increasing the reliability of the electrical system is inextricably linked to increasing the efficiency of controlling its modes. Automatic control of the operating modes of the electrical system is a hierarchical system and is carried out by coordinated actions of personnel at different levels of management. For higher levels of management, the division of personnel functions into groups of technological tasks is characteristic. For example, the central dispatch center includes personnel for mode calculations, mode optimization, and operational personnel. In the relay protection service, part of the personnel performs calculations for the design and analysis of relay protection. Information and application software is also functional in nature (calculation of short-circuit currents, calculation of steady-state mode, mode optimization, etc.).

For effective information support of decisions of personnel of local objects of the electric system it is necessary to carry out analysis of technological tasks which are a set of functional. Personnel should promptly assess efficiency of the approved decision. Such assessment is possible only when using modeling which allows to promptly form different variants of models.

In [1, 2], the results of the analysis of the principles of construction and features of complete and basic simplified models of transient and steady processes in complex electric power systems are presented. However, the analysis does not fully consider the issues of modeling based on modern information technologies.

The software packages used today use external logical models in accordance with modern information technologies, which leads to certain difficulties in user interaction with a PC when conducting various studies. This is due to objective factors.

The initial steady-state operation mode of the electrical network is described by a system of algebraic equations obtained using the nodal voltage method (1).

When studying transient regimes, the following mathematical model is used:

$$G \cdot U = I + I' + I_{Б}, \quad (1)$$

where G is the conductance matrix; U is the vector of instantaneous voltage values at the nodes; I is the vector of instantaneous current values at the nodes, determined by the solution of differential equations describing generators or motors connected at the nodes; *I* is the vector of products of current derivatives at constant times, determined as the ratio of the increase in current over an interval to the duration of the interval; I_b- current vector, which depends on the presence of a connection with the balancing node (the components are determined by the rule: equal to 0 if the node has no connection with the balancing node, otherwise equal to the product of the conductivity and the voltage of the balancing node).

At each interval d with known values $\dot{i}_m^{k-1}$, $\frac{d\dot{i}_{m-n}^{k-1}}{dt}$ there are voltages in the nodes, currents in the branches:

$$u^k = G^{-1}\left[I + I^{/} + I_0\right], \quad i_{m-n}^k = \frac{L_{m-n}}{r_{m-n}} \cdot \frac{di_{m-n}^{k-1}}{dt} + \frac{u_m^k}{r_{m-n}} - \frac{u_n^k}{r_{m-n}}$$

In this case, the specified currents in the nodes are found based on the solution of systems of equations describing transient processes in generators and motors. The derivative currents can be defined as follows [3]:

$$\frac{di_{m-n}^k}{dt} = \frac{i_{m-n}^k - i_{m-n}^{k-1}}{\Delta t},$$

$$L_{m\text{-}n}\frac{di_{m-n}}{dt} + r_{m-n}i_{m-n} = u_m - u_n$$

where i_{m-n} - instantaneous current value;

L_{m-n} - inductance of *the t-p* ; r_{m-n} - active resistance of the device

u_m, u_n - instantaneous voltage value at nodes typ.

Based on Kirchhoff's first law, for each node we can write:

$$\sum_{n=1}^{l}\left(\frac{u_m}{r_{m-n}} - \frac{u_n}{r_{m-n}} - \frac{L_{m-n}}{r_{m-n}} \cdot \frac{di_{m-n}}{dt}\right) = i_m$$

where i_m - instantaneous value of the reference current in *node* t (generators, loads);

ℓ - the number of nodes in the circuit. Let us introduce the notation:

$$g_{m-n} = \frac{1}{r_{m-n}}, \qquad -\sum_{n=1}^{\ell} g_{m-n} = g_{nn}, \qquad g_{nn} = -\sum_{n=1}^{\ell}\frac{1}{r_{m-n}}$$

$$\frac{L_{m-n}}{r_{m-n}} \cdot \frac{di_{m-n}}{dt} = i_{m-n}^{/}, \qquad i_n^{/} = \sum_{n=1}^{\ell}\frac{L_{m-n}}{r_{m-n}} \cdot \frac{di_{m-n}}{dt}.$$

Taking into account the notations for each phase, this equation was written in matrix form (1). The equations are solved for each phase separately, which allows the calculation of transient modes in the presence of asymmetry in the network.

To determine the instantaneous values of the generator current, either the full Park-Gorev equations are used for generators located near the disturbance site. Or a simplified model for generators removed from the disturbance site:

When modeling complex systems that include synchronous machines, it is often necessary to anticipate certain changes in the primary circuit during the transient process. Usually, it is worth considering the disconnection of individual machines, load elements, lines, etc. During subsequent operations, such as reconnection, to correctly reflect the processes in the disconnected AC machines, simulation circuits in the form of "current sources" are used.

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