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Definition of the Area of Acceptable Non-Symmetrical Modes in Power Supply Systems

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Abstract: The main tasks solved in the design, construction and operation of power supply systems for industrial enterprises are to optimize the parameters of these systems by choosing the right range of parameters. The reliability of the electrical system and its individual components largely depends on how correctly and fully the dangerous manifestations of the modes arising in it are taken into account, which can be caused both accidentally and intentionally. Their knowledge is necessary, first of all, to prevent the emergence of dangerous regimes and to develop measures to combat their harmful consequences.

Keywords: electrical networks, economic control, supply transformer.

The quality of electric energy, together with the reliability of power supply and its efficiency, is one of the most important requirements for the system of production, transmission and consumption of electricity. The intensification of production leads to an increase in the power of nonlinear, asymmetric and sharply alternating (shock) loads in industrial enterprises. All this has led to a significant increase in the level of electromagnetic interference in the electrical networks of enterprises and power systems, which, varying in nature, nature of change and intensity, have an adverse effect on power electrical installations, automation and telemechanic systems, communications and relay protection.

As a rule, transverse asymmetry is observed in these networks, caused by the connection of various kinds of single-phase electrothermal and other devices at enterprises of various industries. Longitudinal asymmetry is much less common when a phase break has occurred in one of the elements of the electrical network and electricity is transmitted through this element in two phases. Such modes can exist for a short time and for a long time. Short-term modes are caused, as a rule, by the occurrence and subsequent elimination of short circuits, phase-by-phase disconnections and switching on of switches and other switching devices.

Distorting power flows reflect the power losses in the SES elements from the flow of currents of the corresponding sequences. The greatest distorting power and voltage flows of individual sequences occur at the terminals of an asymmetric load and decrease as they move away from it. The significant spread of asymmetric loads leads to significant violations of the symmetry of currents and voltages in three-phase electrical networks, especially distribution networks. The consequence of the phase asymmetry of currents is the "skew" of the secondary voltage star of distribution transformers and the occurrence of additional losses in the modes of an asymmetric phase load.

Additional tasks arise under operating conditions. Systematic monitoring of asymmetry indicators in industrial networks is required (as a rule, this control should be statistical). For the full use of additional balancing devices and comprehensive technical and v of the current regime, special training of operational personnel should be carried out. Specific decisions have already been made for a number of installations. Individual single-phase electrothermal installations are equipped with special balancing devices.

The reliability of the research results is confirmed by the following: the correctness of the initial assumptions; the correct use of proven mathematical models of SES elements up to 1 kV; a good coincidence of the results of computational and experimental studies with various observational data on the consequences of real asymmetric and incomplete phase modes in SES up to 1 kV; a good explanation of the results of computational experimental studies by the physics of non-symmetric modes.

The most time-consuming and responsible stage of computational research is the preparation and loading of initial data. Previously, it is necessary to mark up the SES circuit by numbering the elements of the electrical network, the nodes of the replacement circuit, load nodes, switches, synchronous and asynchronous motors of the SES. In addition to the numbers, symbolic (letter) designations are provided for the elements of the electrical network and load nodes, which make it easy to identify the necessary network elements and load nodes in the printouts of the calculation results. Uploading the source data about the FEZ to the files .DAT and VOL.DAT is carried out according to a special program for the preparation of initial data. The load node simulates a section of a switchgear to which an arbitrary number of synchronous and asynchronous motors are connected, as well as a three-phase symmetrical other load set by active and reactive power. The absence of any of the loads in the node is reflected by setting zero values of the corresponding capacities.

Algorithms have been developed for calculating the mode for the components of the reverse and zero sequences in the incomplete phase mode of SES up to 1 kV by converting the EMF sources of the reverse and zero sequence at the point of phase interruption into two additional sources of nodal currents for the components of the reverse and zero sequences. The algorithms are based on the nodal stress method.

For four-wire electrical networks, transformers with circuits for connecting windings Y/Un, D/Un, Y/ZH can be used. Transformers with a Y/YH connection scheme, the simplest in design and cost-effective in terms of material consumption, are still not widely used due to the high resistance of the zero sequence. The A/YH connection scheme is more preferable. The lowest resistance of the zero sequence can be obtained at Y/ZH, however, the transformer windings are switched on according to this scheme at a transformer power of 250 kVA or lower. The considered power supply schemes (Fig. 3.1-3.6) with a transformer capacity of 1600 kVA, which excludes the possibility of conducting computational and experimental studies using the Y/ZH connection scheme.

Based on the patterns of distribution of reverse and zero-sequence currents caused by an asymmetric load across the elements of the SES, it can be assumed that the main factor determining the range of permissible asymmetric loads is the nature of the electrical load in the SES up to 1 kV. This is explained by the fact that the motor load has a reverse sequence resistance 5-7 times less than the resistance of the direct sequence, while the non-motor (static) load (according to accepted terminology - other, S^) has a reverse sequence resistance commensurate with the resistance of the direct sequence. The electric motor load accumulates currents of the reverse sequence, reduces the total resistance of the reverse sequence of the SES and, thereby, reduces the voltage of the reverse sequence with an asymmetric load.

The range of permissible modes of single-phase load in the reverse sequence depends on the nature of the load in the SES, on the remoteness of the connection point of the asymmetric load and the cross section of the supply cable cores. However, due to the fact that the maximum permissible single-phase load for reverse sequence voltages is on average more than 20% of the rated power of the supply transformer, there are no special problems with the asymmetry of reverse sequence voltages in workshop SES up to 1 kV. The range of permissible modes of single-phase zero-sequence load depends on the wiring diagram of the transformer windings of the workshop substation, on the remoteness of the connection point of the asymmetric load and the cross section of the zero core of the supply cable. The maximum permissible single-phase load for the zero sequence voltage is on average from 1.3 to 23% of the rated power of the supply transformer, and this is almost ten times less than for the reverse sequence voltage.

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