СЕКЦІЯ 12

SECTION 12

ЕЛЕКТРОНІКА, АВТОМАТИЗАЦІЯ І ЕЛЕКТРОННІ КОМУНІКАЦІЇ
ELECTRONICS, AUTOMATION AND ELECTRONIC COMMUNICATIONS

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USING THE SYMBOLIC METHOD FOR CALCULATING THREE-PHASE CIRCUITS

A three-phase circuit is a set of three electrical circuits in which sinusoidal EMFs of the same frequency operate, shifted from each other by an angle of 120° in phase, which are created by a common source. In this case, the source is considered symmetrical, and the set of voltages that are output is a symmetrical system of voltages. If the same load resistances are included in each phase (for example, the stator windings of an asynchronous motor), then such a load is symmetrical, and the circuit operating mode is also called symmetrical. Almost 90% of all electricity generated is consumed in symmetrical modes.

Since a three-phase circuit is a combination of three sinusoidal current circuits, their calculation can be carried out by analogy with such circuits. However, this approach is not always simple, especially in the case of an asymmetrical load.

Vector diagrams are widely used for the analysis and calculation of three-phase sinusoidal current circuits [1]. This is due to the fact that, in addition to the phase shift by an angle of 120° of the voltages, additional phase shifts between the current and voltage can be different due to the unequal complex resistances of the phases. In addition, in the case of an asymmetrical load, the symmetry of the voltages of consumers can be violated. In this case, the calculation of a three-phase system cannot be reduced to the calculation of circuits of individual phases with the same voltages. When calculating circuits, it is most often necessary to determine the currents in the circuit and in the supply conductors, as well as the power consumed by individual phases and the circuit as a whole, from known voltages and phase

resistances. Calculations are performed similarly to single-phase alternating current circuits. For a symmetrical load, the currents in each phase are the same, and the phase shift angles are the same. Under these conditions, it is sufficient to perform calculations for one phase.

The case of an asymmetrical load is more complicated. If the circuit has a symmetrical system of voltages of the same magnitude and shifted in phase by 120°, the combination of the calculation method with the graphic method (vector diagrams) can be quite effective. At the same time, it should be taken into account that the graphic method of analyzing a three-phase circuit, despite its clarity, is approximate.

It is more appropriate for the case of three-phase circuits to use the symbolic method, which consists in representing the quantities characterizing the circuits (EMF, currents, voltages, resistances) in a complex form. The advantages of the symbolic method are that in the complexes of physical quantities characterizing the phases, phase angles are immediately taken into account, while the symbolic method gives an accurate result, moreover, in an analytical form.

The symbolic method is practically the only calculation method in the case of connecting asymmetrical consumers according to the “star without neutral” scheme, in which the symmetry of the voltages is broken (both in magnitude and in phase shift). In this case, the use of complexes of voltages and resistances or conductivities makes it possible to calculate the neutral displacement voltage, find the voltage in each of the phases and then calculate the currents [2].

References

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