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The flower of the electrical neutral in the topological Yu. G. Vedmitskyi mapping. The method of comparable asymmetry

The article proposes a new method for analyzing multi-phase electrical circuits – the method of comparable asymmetry. The study was conducted using the basic principles of the theory of a generalized electric circuit, which took into account the physical phenomenon of hypervalent interaction between the typical elementary links of a dynamic system.

The article presents the theoretical foundations of a new method for analyzing *multiphase electrical circuit systems* (fig. 1). The method was named the *method of comparable asymmetry*.

The *main idea* of this method is to compare all possible (in this case, asymmetrical) states of a multiphase system of electrical circuits with its particular state – the state of symmetry. This comparison is carried out depending on the values of the relative deviations of the parameters of the elements of the system from those values of the parameters that create the state of symmetry.

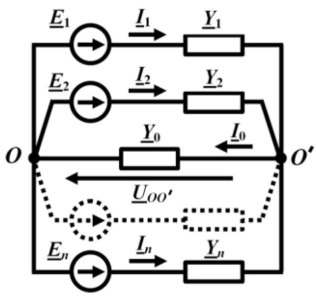

Fig. 1. Multi-phase electrical circuit systems

The main idea of the method cannot be implemented in the coordinate space of *absolute* physical quantities (voltages of energy sources $\underline{E}_v$ and conductances $\underline{Y}_v$ of electrical phases). But in the case of constructing the coordinate space of *relative* physical quantities, the creation of a method of comparable asymmetry becomes possible. This generates the task of transforming one coordinate space into another.

For the symmetry region of the studied electrical circuits, this problem is converted into a topological mapping problem of *one-dimensional* or *multidimensional* symmetry regions (in the coordinate space of absolute physical quantities) into a *zero-dimensional* symmetry region (in the coordinate space of relative physical quantities). This task is called the *zero-dimensional problem*.

The object of mathematical research is the complex of the effective value of the bias voltage of the neutral $\underline{U}_{O'O}$. This voltage depends on the parameters of the elements of the electrical circuit and is a function of many complex variables. The specified voltage is a very important electrical parameter of multiphase systems, since it is capable of detecting the fact and degree of power interaction between individual structural elements of a dynamic system – *typical elementary units*. According to the theory of a *generalized electric circuit* [1-4], typical elementary units in multiphase systems are *electrical phases*. In our case, such structural units are formed using a

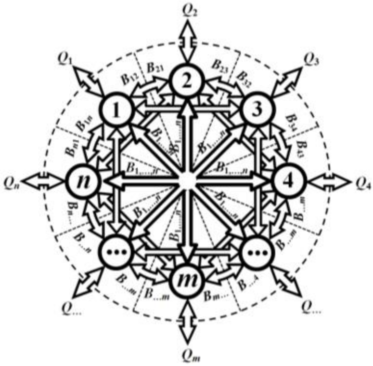

Fig. 2. Block diagram of a generalized dynamic system, taking into account the physical phenomenon of hyper-force (hypervalent) interaction

conductive connection between the multi-phase system of energy sources and the multi-phase system of its consumers. The topology of these systems is $(n+1)$-ray stars architecture (fig. 1). In accordance with the *physical phenomenon of hyper-force* (*hypervalent*) *interaction between typical elementary units in a generalized dynamic system with lumped parameters* (fig. 2), the internal force interaction in the structural-topological space of the multiphase systems under study is *multidimensional* (*n*-dimensional). This physical phenomenon has a general scientific character and was first described in articles [2-4]. The priority of scientific discovery belongs to Ukraine.

In differential form, the indicated multidimensional hyper-force is detected and determined by the *structural equations of a dynamical system* [2-4] in the form of a reusable sum. In our case, these equations are written as

$$\left(L_\nu \frac{di_\nu}{dt} + R_\nu i_\nu + \frac{q_\nu}{C_\nu}\right) +$$

$$+\sum_{\substack{s_1=1 \\ s_1\neq\nu}}^{2} \sum_{\substack{s_2=s_1+1 \\ s_2\neq\nu}}^{3} \cdots \sum_{\substack{s_{n-1}=s_{n-2}+1 \\ s_{n-1}\neq\nu}}^{n} \left[L_{\nu,s_1,s_2,\ldots,s_{n-1}} \frac{d}{dt}\left(i_\nu \pm i_{s_1} \pm i_{s_2} \pm \cdots \pm i_{s_{n-1}}\right) + \right. \tag{1}$$

$$\left. +R_{\nu,s_1,s_2,\ldots,s_{n-1}} \left(i_\nu \pm i_{s_1} \pm i_{s_2} \pm \cdots \pm i_{s_{n-1}}\right) + \frac{q_\nu \pm q_{s_1} \pm q_{s_2} \pm \cdots \pm q_{s_{n-1}}}{C_{\nu,s_1,s_2,\ldots,s_{n-1}}} \right] = e_\nu,$$

$\nu = 1, 2, \ldots, n.$

In a complex form, the system of equations (1) has the form

$$\underline{Z}_\nu \underline{I}_\nu + \underline{U}_{O'O} = \underline{E}_\nu, \quad \nu = 1, 2, \ldots, n, \tag{2}$$

$\underline{U}_{O'O} = \dfrac{U_{m_{O'O}}}{\sqrt{2}} e^{j\psi_u}$ – the complex of the effective value of the neutral bias voltage,

$\underline{E}_\nu = \dfrac{E_{m_\nu}}{\sqrt{2}} e^{j\psi e_\nu}$ – voltages of energy sources, $\underline{Z}_\nu = R_\nu + j\left(\omega L_\nu - \dfrac{1}{\omega C_\nu}\right) = \underline{Y}_\nu^{-1}$ – complex impedances.

From the system of equations (2) we have

$$\underline{U}_{O'O}\left(\underline{E}_v, \underline{Y}_v, \underline{Y}_0\right) = \frac{\sum_{v=1}^{n} \underline{E}_v \underline{Y}_v}{\underline{Y}_0 + \sum_{v=1}^{n} \underline{Y}_v} . \qquad (3)$$

The equation (3) determines the neutral bias voltage as a function of several complex variables $\underline{U}_{O'O}\left(\underline{E}_v, \underline{Y}_v, \underline{Y}_0\right)$, $1 \le v \le n$, which is given in the coordinate space of absolute physical quantities. We define this function in the coordinate space of relative physical quantities

$$\underline{U}_{O'O}\left(\underline{E}_v, \underline{Y}_v, \underline{Y}_0\right) \Rightarrow \underline{U}_{O'O}\left(\underline{E}_v, \underline{\delta}_v, \underline{\delta}_0\right).$$

We use for this the *following* transformation of the coordinate space:

$$\underline{U}_{O'O}\left(\underline{E}_v, \underline{Y}_v, \underline{Y}_0\right) = \frac{\sum_{v=1}^{n} \underline{E}_v \underline{Y}_v}{\underline{Y}_0 + \sum_{v=1}^{n} \underline{Y}_v} = \frac{\sum_{v=1}^{n} \underline{E}_v \frac{\underline{Y}_v}{\underline{Y}_1}}{\frac{\underline{Y}_0}{\underline{Y}_1} + \sum_{v=1}^{n} \frac{\underline{Y}_v}{\underline{Y}_1}} =$$

$$= \frac{\sum_{v=1}^{n} \left[\underline{E}_v + \underline{E}_v \left(\frac{\underline{Y}_v}{\underline{Y}_1} - 1 \right) \right]}{\left[1 + \left(\frac{\underline{Y}_0}{\underline{Y}_1} - 1 \right) \right] + \sum_{v=1}^{n} \left[1 + \left(\frac{\underline{Y}_v}{\underline{Y}_1} - 1 \right) \right]} = \frac{\sum_{v=1}^{n} \underline{E}_v + \sum_{v=2}^{n} \underline{E}_v \underline{\delta}_v}{n + 1 + \underline{\delta}_0 + \sum_{v=2}^{n} \underline{\delta}_v} = \qquad (4)$$

$$= \frac{\sum_{v=2}^{n} \underline{E}_v \underline{\delta}_v}{n + 1 + \underline{\delta}_0 + \sum_{v=2}^{n} \underline{\delta}_v} = \underline{U}_{O'O}\left(\underline{E}_v, \underline{\delta}_v, \underline{\delta}_0\right).$$

In the transform (4) $\underline{\delta}_v = \frac{\underline{Y}_v - \underline{Y}_1}{\underline{Y}_1} = \frac{\underline{Y}_v}{\underline{Y}_1} - 1$ – these are the *relative deviations of the complex conductances* of the loads relative to the load of the main phase. In the same way, we determine the relative deviation of the complex conductivity $\underline{\delta}_0$.

Transformation (4) is correct under the condition of symmetry in a multiphase system of energy sources: $\sum_{v=1}^{n} \underline{E}_v = 0$.

We introduce a non-system physical quantity – the *specific bias voltage of the neutral* $\underline{\aleph}$, which we define as a function

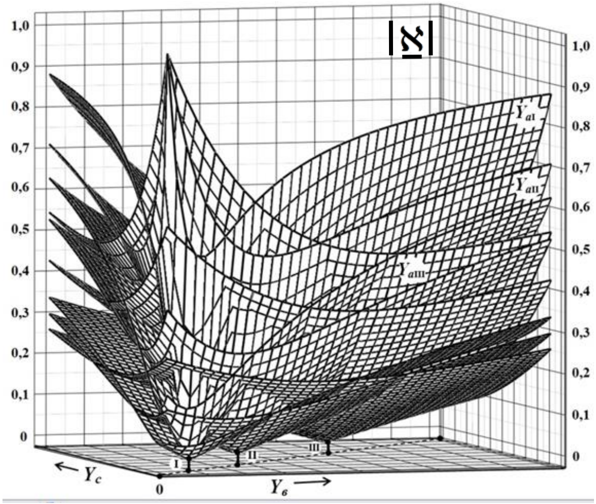

Fig. 3. The bouquet of flowers
of the electrical neutral in the coordinate space
of *absolute* physical quantities

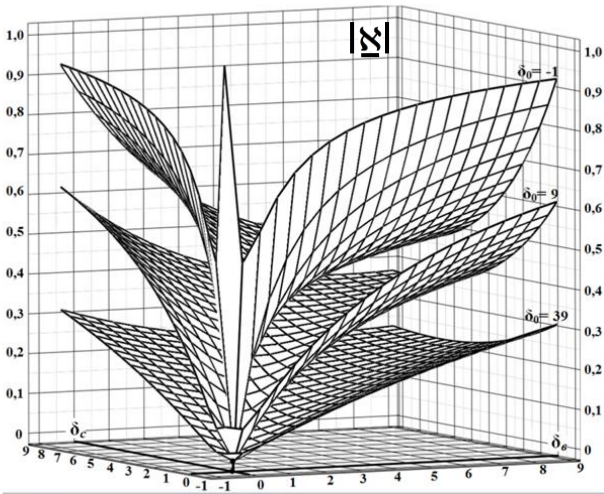

Fig. 4. The flower of the electrical
neutral in the coordinate space
of *relative* physical quantities

$$\underline{\aleph} = \frac{\underline{U}_{O'O}}{\underline{E}_1} = \frac{\underline{U}_{O'O}}{E_1} .$$

This function in the coordinate space of *absolute* physical quantities has the form

$$\underline{\aleph}\left(\underline{Y}_v, \underline{Y}_0\right) = \frac{\sum_{v=1}^{n} a^{1-v}\underline{Y}_v}{\underline{Y}_0 + \sum_{v=1}^{n}\underline{Y}_v} ,$$

in the coordinate space of *relative* physical quantities –

$$\underline{\aleph}\left(\underline{\delta}_v, \underline{\delta}_0\right) = \frac{\sum_{v=2}^{n} a^{1-v}\underline{\delta}_v}{n + 1 + \underline{\delta}_0 + \sum_{v=2}^{n}\underline{\delta}_v} ,$$

$a = e^{j\cdot\frac{2\pi}{n}}$ – rotation operator.

We have shown in fig. 3 in fig. 4 for the case of three-phase circuits without reactive loads three groups of graphic surfaces of the function of the *modulus* $\left|\underline{\aleph}\right|$ of the specific bias voltage of the neutral. The region of symmetry of electrical circuits is *one-dimensional* in the coordinate space of absolute physical quantities (fig. 3). The same area will be *zero-dimensional* in the coordinate space of relative physical quantities (fig. 4). The author named each group of such surfaces as a *flower of the electrical neutral*.

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