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THE UNBALANCED STATE SIMULATION

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ABSTRACT
The unsymmetrical state appreciation can only be based on symmetrical components, determined using the Stokvis-Fortescue theorem. Emphasis is important because of the proliferation of calculus relations that characterize the unsymmetrical state, including relations implemented in such equipment or Powermeter, Qualymeter.
Considering a system of three sizes phasor (Y1, Y2 and Y3) we can state that correspond to six scalars, three amplitudes (effective values) and three phasors. In the case treated below, is considered one of a three sizes as a reference (Y1) and the other two phasors are expressed as the reference phasor, as follows: Y2/Y1 and Y3/Y1. To check the symmetrical components calculus relation on a domain as wide as the asymmetry coefficient (negative unbalanced factor), the simulation of asymmetrical state, which can be made by varying the following parameters:
- varying the phase angle;
- the system phase amplitudes ratio modification with varying of phase angle between successive phasors, between the same limits, as above.

Keywords: phasor, symmetrical components, asymmetry coefficient

1.SYMMETRICAL COMPONENTS CALCULUS

The symmetrical components are calculated strictly based on the following relations, which are, however, the disadvanced that they are expressed in complex, with fewer programming fields, designed to work in this plan:

$$\underline{Y}_d = \frac{1}{3}\cdot\left(\underline{Y}_1 + a\cdot\underline{Y}_2 + a^2\cdot\underline{Y}_3\right)$$
$$\underline{Y}_i = \frac{1}{3}\cdot\left(\underline{Y}_1 + a^2\cdot\underline{Y}_2 + a\cdot\underline{Y}_3\right) \qquad (1)$$
$$\underline{Y}_h = \frac{1}{3}\cdot\left(\underline{Y}_1 + \underline{Y}_2 + \underline{Y}_3\right)$$

where $a=e^{j2\pi/3}$ is the rotation operator and $\underline{Y}_1$, $\underline{Y}_2$, $\underline{Y}_3$ are the phasors of the three-phased system (voltages or currents). So, the calculation of the operating states for unbalanced networks is made using the symmetrical components.

2.THE UNBALANCED STATE SIMMULATION

Considering a system of a three sizes phasor ($\underline{Y}_1$, $\underline{Y}_2$ and $\underline{Y}_3$), we can state to correspond to six scalars three amplitudes (the effective values) and three phases. In the case treated below, is considered one of the three phases as a reference ($\underline{Y}_1$) and the other two phasors are expressed as the reference phasor, as follows: Y_2/Y_1 şi Y_3/Y_1. $\underline{Y}2$ andi $\underline{Y}_3$ phasor modules is indicated by reports that Y_2/Y_1 and Y_3/Y_1 respectively through the Y1 reference. The $\underline{Y}_2$ şi $\underline{Y}_3$ phases are indicated reporting by the $\underline{Y}_1$ reference phasor, which is considered phase φ_1=0. Therefore, the three systems of three phasors presents only four degrees of freedom, corresponding to two amplitudes ratio Y_2/Y_1 şi Y_3/Y_1 and the two phases φ_{12} şi φ_{23}, between the reference phasor and the third phasor, respectively between the second and third phasors.

For checking the symmetrical components calculus relations on a field as wide of dissymmetry coefficient (the negative asymmetry factor) is necessary the simulation of unsymmetrical state, which can be made varying the following parameters:

-Varying the phase shift angle, defined by the relation $\varphi = \varphi_{12} = \varphi_{23}$ and therefore $\varphi_{13} = 2\varphi$. It is considered that the phase shift angle can takes values in the interval $[-2\pi/3, 4\pi/3]$, providing a large domain of unsymmetrical state, starting of the direct sequence system (or positive), for which $\varphi=-2\pi/3$, through homopolar sequence (or zero), for which $\varphi=0$ and reaching the inverse sequence (negative), for which $\varphi=2\pi/3$, considering, first, that the system measures component amplitudes are equals, $Y_2/Y_1 = Y_3/Y_1 = 1$, $Y_2/Y_1 \in [0, 1]$, $Y_3/Y_1 \in [0, 1]$.

-the ratio modification between the system phasors amplitude by varying the phasor angle between the successive phasors, between the same limits, as above.

The mentioned values domain covers the entire possible domain, if considered the $\underline{Y}_1$ phasor with the largest module. The successive phasors phase angle generation leading to a phase shift angle between the third and the first phasor, one taken as reference, given by the relation:

$$\varphi_{31}=2(\pi-\varphi), \tag{2}$$

so, the three phased system resulting symmetric for $\varphi=\pm 2\pi/3$, but with different successions, when, in addition, the modules ratio are unitary.

In the next figures are presented the symmetrical components reporting to the phase angle between two successive phasors, for four distinctively situations looking the ratio between the phasors amplitude (the reference phasor amplitude was taken as 100).

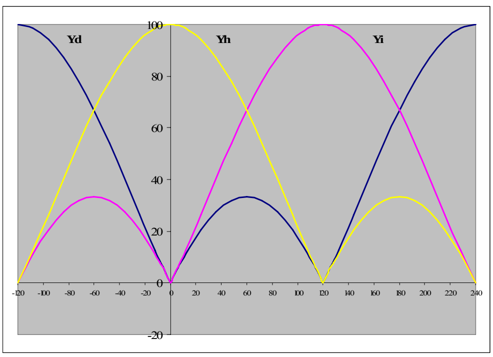

Figure 1. The symmetrical components variation reported to the successive phasors phase angle, in case of the equal amplitudes phasors

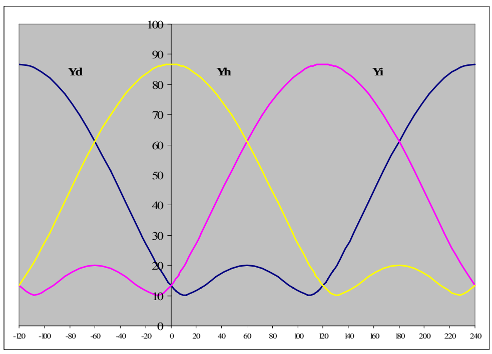

Figure 2. The symmetrical components variation reported to the successive phasors phase angle, in case of $Y_2/Y_1=1$, $Y_3/Y_1=0.6$

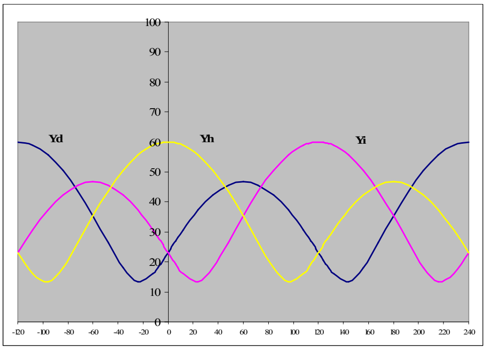

Figure 3. The symmetrical components variation reported to the successive phasors phase angle, in case of $Y_2/Y_1=0.2$, $Y_3/Y_1=0.6$

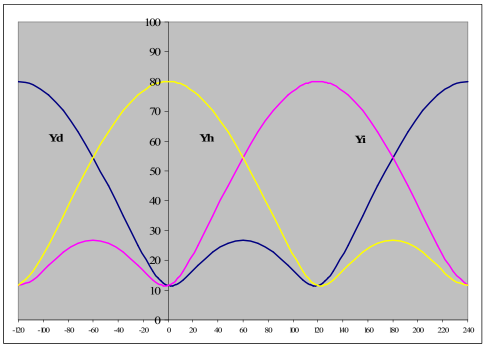

Figure 2. The symmetrical components variation reported to the successive phasors phase angle, in case of $Y_2/Y_1=0.8$, $Y_3/Y_1=0.6$

In the first case, of equal amplitudes, when $Y_2/Y_1=1$, $Y_3/Y_1=1$, we observe that the direct component amplitude Y_d decrease to the maximum value $Y_{dmax}=100$, registered for $\varphi=-2\pi/3$, to zero, when the φ phase shift angle increases from $(-2\pi/3)$ to zero; to further the growth of φ variable from zero to $(2\pi/3)$, the Y_d component variation is the sinusoidal one, whit a local maximum, $Y_d = 33.33$, for an angle $\varphi = \pi/3$.
The variation function for inverse succession component Y_i is symmetrical reported to the ordinate axis, reporting to the Y_d direct component variation function. Regarding the Y_h homopolar component, is zero at the ends of a φ angle variation range, to achieve the maximum $Y_{hmax} = 100$, for $\varphi = 0$.
The second case approach the situations when the ratio of amplitudes are considered $Y_2/Y_1= 1$ şi $Y_3/Y_1 = 0.6$. In this case is observing that the amplitudes of the three symmetrical components (Y_d, Y_i şi Y_h) are similar like shape with the first case one, except that their ranges are in interval Y = [10, 86.67] and the unsymmetrical state described in this way is never "pure" direct, inverse or homopolar.
The amplitude of the Y_d direct component decrease from the $Y_{dmax}=86.67$ maximul value, obtained for $\varphi=-2\pi/3$, to the 13.33 value, when the φ shift angle growth from $(-2\pi/3)$ to zero; further the growth of φ variable from zero to $(2\pi/3)$, the Y_d variation is the sinusoidal one, with a $Y_d = 20$ local maximum for $\varphi = \pi/3$ angle.
The variation function of the Y_i inverse component is symmetrical reporting to the ordinate axis, regarding the Y_d direct component variation function. As for the Y_h homopolar component, is equal with 13.33 to the ends of ranges of variation of φangle, to achieve the $Y_{hmax} = 86.66$ maximum, for $\varphi = 0$ angle.
The third case, when for the amplitudes ratio was consideres the $Y_2/Y_1=0.2$ şi $Y_3/Y_1=0.6$ values, disclose the fact that the direct and inverse amplitudes representations have not the minimum values in the origin, these being displaced in relation to this to $\varphi = -24^o$ for Y_d, respectively to $\varphi = 24^o$, for Y_i.
The amplitude of Y_d direct component decrease from the $Y_{dmax}=60$ maximum values, registered for $\varphi=-2\pi/3$, to the 13.31 value, when the φ phase angle growth from $(-2\pi/3)$ to $(-2\pi/15)$; further increasing of φ variable from $(-2\pi/15)$ to zero, the Y_d is the exponential one, with a 23.09 value in origin, having, then, for the interval $(0, 2\pi/3)$, a sinusoidal variation with a $Y_d = 46.67$ local maximum, for $\varphi = \pi/3$ angle.
The variation function of a Y_i inverse succession component is symmetrical reporting to the ordinate axis, reporting to the Y_d direct component variation. Regarding the Y_h homopolar component, is equal with 23.09 to the ends of a range of φ angle, to achieve the $Y_{hmax} = 60$ maximum for $\varphi = 0$.
The last case, when is consideres the $Y_2/Y_1= 8$ şi $Y_3/Y_1 = 0.6$, reveal the fact the amplitudes of the symmetrical components (Y_d, Y_i şi Y_h) have similar shape with the first cases, the difference being the interval of variation, which now is Y = [10, 80] and the unsymmetrical state described is not, also, "pure" direct, inverse or homopolar. For the same previous cases, is presented the K_{id} negative asymmetry factor variation and K_{hd} zero asymmetry factor reported to the φ variable, represented the

phase angle between the two phasors. Clearly, as the difference between the phasors amplitudes decrease, the values of the both fields of unbalanced state are reduced.

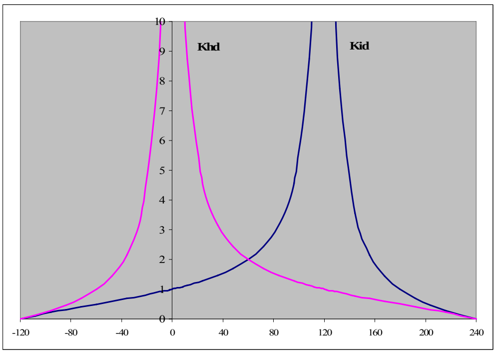

Figure 5. The equal amplitude phasors

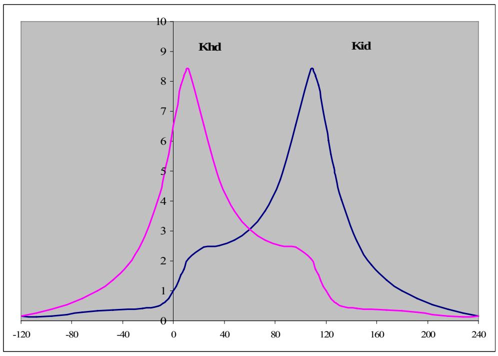

Figure 6. $Y_2/Y_1=1$, $Y_3/Y_1=0.6$

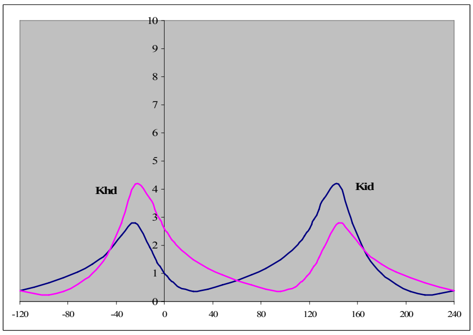

Figure 7. $Y_2/Y_1=0.2$, $Y_3/Y_1=0.6$

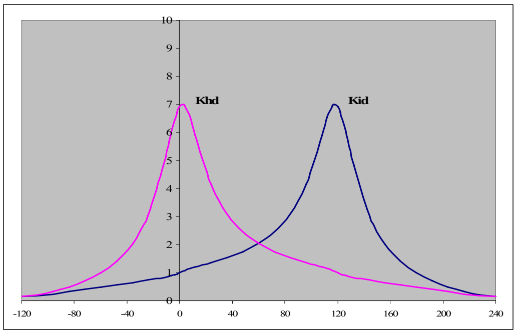

Figure 8. $Y_2/Y_1=0.8$, $Y_3/Y_1=0.6$

Generation of unsymmetrical sizes, whose system has the negative unsymmetry factor in a large value domain, it was made in a wide range of values, in the case of null zero sequence component and for the case when this component in not null.

3. CONCLUSIONS

Unbalanced system of phasors generation is simple and efficient method proposed, named a equal modules and a phase shift angle, consecutive, equals. Simplicity is derived from the single variable, namely the φ angle between the two consecutive phasors, and the efficiency is sustained by a full domain, from zero to the plus infinity, for both indicators of unsymmetrical state, like the dissymmetry and asymmetry coefficients.

The analytical study of symmetrical components and a dissymmetry and asymmetry coefficients and graphical representations of the corresponding functions for these parameters, to the whole interest domain, facilitates the understanding and mastery of of phenomena related to unbalanced states.

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