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Equation of Movement of Subharmonic Oscillations in Three-Phase Chains with Three-Phase Ferromagnetic Elements

Tovboyev A.N., Norqulov A.O., Togaev I.B.,

Candidate of Technical Sciences. NSMI
Assistant of «Electrical power engineering» Department. NSMI
Candidate for a master degree of «Electrical power engineering» Department. NSMI

ABSTRACT: This article examines the mode of initiation of third-order subharmonic oscillations in a three-phase chain consisting of active, capacitive and non-linear inductive elements (the latter have a common magnetic connection) that are analogous to "Line-unloaded transformer" transmission lines. The three-phase system under consideration, each phase of which consists of a sequentially connected three-phase ferro of magnetic element, capacity and active resistance. Motion equations are revealed. It is considered to analyze the phenomenon of internal overexertion caused by the occurrence of subharmonic fluctuations in power lines.

KEYWORDS: subharmonic fluctuations, auto-parametric fluctuations, electroferromagnetic circuit, non-linear circuit, ferromagnetic element, frequency converter, of course-different methods, numerical methods.

I.INTRODUCTION

Currently, in various industries of electric power: automatic devices, telemechanics, inpharmacy and measuring equipment, relay protection and other widely used are found various kinds of energy converters, number of phases and frequencies, based on auto-parametric oscillations in three-phase non-linear chains about concentrated parameters.

The phenomena of internal overexertion in power lines (PL), detected due to the excitement of auto-parametric fluctuations, served as the impetus for the detailed study of the properties of multiphase systems. Equally, the probability of initiating auto-parametric fluctuations at a particular frequency depends on the mode and conditions of power lines and electricity consumers.

One of the dangerous modes of power lines is overexertion, which arises due to the excitement of subharmonic fluctuations, which appear mainly under switching conditions.

To analyze the phenomenon of internal overexertion caused by subharmonic fluctuations in power lines, many authors looked at three-phase models of power lines with concentrated parameters. Although this approach did not take into account the distribution of the parameters of the power line, the processes taking place in the latter to some extent reflect the physics of the issue, on the other hand, the analysis of non-linear fluctuations in the three-phase chains, in particular, in the mode initiation of subharmonics, reveals the features and features of three-phase systems from the point of view of chain theory [1, 2, 3, 4].

Using the averaging method with the appropriate phases, shortened equations are obtained. From the conditions of the periodic solution are defined phase ratios, different from phase ratios for three-phase chains with group ferro magnetic elements. In the stationary mode, conditions of arousal, area of existence, dependence of output values on chain parameters and applied impact are defined. The sustainability of the solution is also investigated by analyzing the roots of the characteristic equation and qualitatively providing a numerical implementation of the original system of non-linear heterogeneous differential equations of the second order, describing the numerical implementation of the original system of non-linear heterogeneous differential equations of the second order, describing the the chain in question.

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II. RESULTS AND DISCUSSIONS

In the analysis, the following assumption is made: the non-linear dependence of the weber-ampular characteristics of the magnetic element ferro is different from linear by order μ, where $0 < \mu < 1$

The three-phase system under consideration, each phase of which consists of a sequentially connected three-phase ferro of magnetic element, capacity and active resistance. The processes in such a system are described by the following integrative differential equations in a matrix form.

$$U = \mathrm{R}i + \mathrm{C}^* \int i dt + wS\, A^* \dot{B} \qquad (1)$$

Where:

$$\mathrm{R} = \begin{bmatrix} \mathrm{R}_A & -\mathrm{R}_\mathrm{B} & 0 \\ 0 & \mathrm{R}_\mathrm{B} & -\mathrm{R}_\mathrm{C} \\ -\mathrm{R}_\mathrm{A} & 0 & \mathrm{R}_\mathrm{C} \end{bmatrix}$$

$$\mathrm{C}^* = \begin{bmatrix} C_\mathrm{A}^{-1} & -C_\mathrm{B}^{-1} & 0 \\ 0 & C_\mathrm{B}^{-1} & -C_\mathrm{C}^{-1} \\ C_\mathrm{A}^{-1} & 0 & C_\mathrm{C}^{-1} \end{bmatrix}$$

$$A^* = \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{bmatrix}$$ - square special strand matrix ν (ν -number of phases)

u, i, $\int i$dt, $\dot{B}$ - column matrix of instant values of linear stresses of the symmetrical source of the three-phase voltage, currents of all branches, integrators of current of all branches (phases) and derivative magnetic induction of each rod of the three-phase ferromagnetic element;

$\mathrm{R}_\mathrm{A}, \mathrm{R}_\mathrm{B}, \mathrm{R}_\mathrm{C}$ и $C_\mathrm{A}, C_\mathrm{B}, C_\mathrm{C}$ correspondingly active resistance and capacity in phases.

Since the three-phase unloaded transformer (Figure 2) is considered as a ferro of the magnetic element, the current of each of its high voltage and magnetic field voltages is linked by the following ratios

$$\mathrm{w}A^* i = A^* HL \qquad (2)$$

где; H,L - The column matrix of instant tension values of the magnetic field of the rods of the three-phase ferromagnetic element and its diagonal matrix of the corresponding average lengths of the rods;

w -number of windings of each web

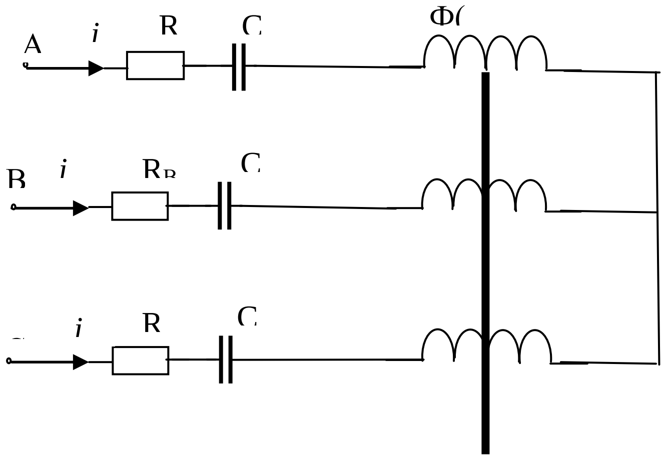

Fig. 1 Taking the core material of the ferromagnetic element isotope and neglecting the active resistance of windings, the dependence of magnetic field tension on induction approximate incomplete polynom. [5]

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$$H=\alpha B+\beta B^3, \qquad (3)$$

where: α = diag[α_ν],
β=diag[β_ν] -diagonal matrix of approximating functions
B^3- column induction matrix to a cubic degree

And so, given the continuity of currents and magnetic flows in the system we have the following equation, ie.

$$\sum_{\nu=1}^{3} i_{\nu=0} \qquad (4)$$

$$W\sum_{\nu=1}^{3} B_{\nu=0} \qquad (5)$$

To bring the equation (2) to a species that is convenient for further use, we allow it to be negatively current. However, immediate resolution is not possible, as Matrix a. is special. Thus, the a'a matrix will be slightly changed, namely elements of the first line of the form from the modified matrix will be subtracted by elements of the third line from the corresponding elements of the first line of the original matrix. Elements of the second line are deducted from the first line, etc. After such elementary operations, instead of the matrix A^*, we will get a matrix that has the following kind

$$\begin{bmatrix}-2 & 1 & 1\\ 1 & -2 & 1\\ 1 & 1 & -2\end{bmatrix}$$

The resulting matrix can be considered as the sum of two submatrix A and B^*, ie

$$A+B^*=\begin{bmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{bmatrix}+\begin{bmatrix}-3 & 0 & 0\\ 0 & -3 & 0\\ 0 & 0 & -3\end{bmatrix} \qquad (6)$$

Square Matrix A in expression (6), the elements of which are only positive units, is special and has special significance for the three-phase system, as the works of columns of current matrix and magnetic induction on A form a zero matrix, i.e.

$$Ai=0, \qquad w\,AB=0. \qquad (7)$$

Taking into account (7) and (6) of the expression (2) we find the current

$$i=\frac{1}{w}(B^{*-1}A\,H\,L+H\,L) \qquad (8)$$

If the diagonal medium-length matrix (L) of the three-phase ferro magnetic element rods present two diagonal submatrixs as the next successive transformation

III. CONCLUSION

The results of the calculations of the equation (8) show that in cases of residual magnetic flow in the cores (initial voltage on the capacity) the jumps of current and voltage in phase and linear wires, as well as on individual elements of the chain, are ten times higher than values, and the duration of the transition process varies from 0.02 seconds. 0.3 sec.

In addition, the solution to the resulting equation (8) allows you to write down equations for each phase separately, containing members with second derivatives induction of the respective phases and the first derivatives inductionofof of all phases, etc.

The equation above allows you to get equations of some sort in a "standard" form that are not subject to any preliminary conversion when using the averaging method.

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