ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 8, Issue 10 , October 2021

Features of auto parametric oscillations at fundamental harmonic in 3-phase electric ferromagnetic circuits with common and separate magnetic circuits

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ABSTRACT:The paper shows that each class of three-phase circuits has its own specific characteristics and it is very difficult to classify them according to their resonance properties. It is defined that if three-phase circuits are strictly symmetrical they are divided into "N" shaped and "S" shaped voltammetry characteristics.

KEY WORDS: Auto oscillation processes, electro-ferro-magnet, multi-phase electric circuits, magnet wire.

I.INTRODUCTION

As it is well known the excitation and maintenance of auto oscillatory processes in multi-phase electro-ferromagnetic oscillation circuits have their own specific features of electro-ferro-magnetic circuits. In multiphase electric circuits containing ferro-magnetic elements and linear capacitances under certain conditions energy conversion occurs in the frequency spectrum, which depends on initial conditions, i.e. on the characteristics of linear and non-linear elements, as well as external influences. The losses formed in the circuit by currents whose frequencies differ from the frequency of the driving force are compensated by the non-linear elements converting the source energy into the frequency-converter energy Any multi-phase non-linear energy system will only operate stably if a certain energy equilibrium exists in the system. The most significant specific feature of multi-phase non-linear circuits is the sub-magnetising effect of one phase on the other. In contrast to linear multiphase circuits, multi-phase nonlinear systems cannot always be seen (even in the presence of perfect symmetry) as superposing three single-phase circuits. These circuits exhibit all the characteristic features of electro-ferromagnetic circuits with many degrees of freedom. A characteristic feature of self-oscillation in multiphase circuits is the presence of an excitation "threshold", i.e. the onset of intensive rise of voltage and current amplitudes on the reactive elements to a certain value. In this case the amplitudes strictly correspond to the electromagnetic energy stored in the system. After excitation of auto oscillations in the system the accumulated energy is self-regulating in accordance with the parameters of the energy-consuming elements.

One of the features of multi-phase oscillating circuits is the synchronous excitation of oscillations in all phases. At an initial increase in voltage up to a certain value, the system behaves in a linear fashion, i.e. all the phase quantities change proportionally - there is a phase-by-phase accumulation of energy, which leads to an increase in the amplitude of the oscillation. When the energy balance of the system reaches a critical value, the system simultaneously increases in amplitude in each phase, i.e. the system enters a new steady state. The amplitude is set in each phase at once.
In 3-phase circuits with magnetic coupling between the phases (Fig.1) without a neutral conductor and with a neutral conductor due to the non-uniform magnetic paths of each phase, there is non-symmetry of the magnetising currents. The three electromotive forces induced in the three phases correspond to three magnetic fluxes, different in their amplitudes and shifted by 120°, i.e.

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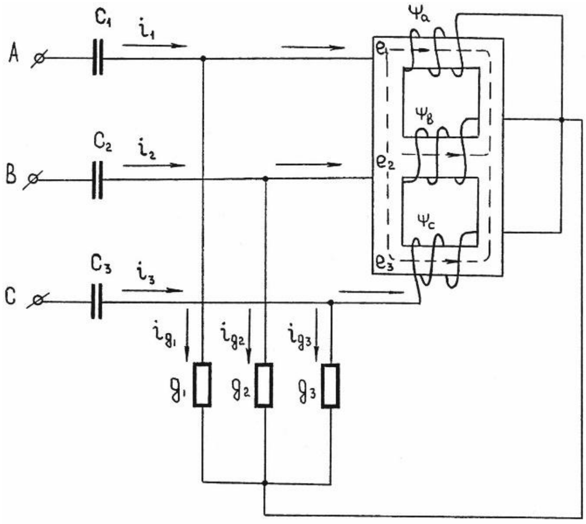

Figure 1. Three-phase ferroresonant AP circuit with magnetic coupling between phases without a neutral conductor.

II. METHODOLOGY

For forward and reverse currents, there is a magnetic flux return circuit through the other cores and thus the magnetising impedance is very high. The features of ferromagnetic coupling are revealed by an experimental study of the self-oscillation in the circuit in figure 1. With a smooth increase in the voltage in all three phases, the following modes are observed: as soon as the effective value of voltage of power supply reaches a certain value in the system, the simultaneous auto-oscillation, the largest amplitude of which is set after 8-10 periods of applied voltage (Fig.2, **a** and **b**) are initiated. The magnetising currents of each phase, due to iron saturation, will consist of basic and higher harmonic sinusoids.

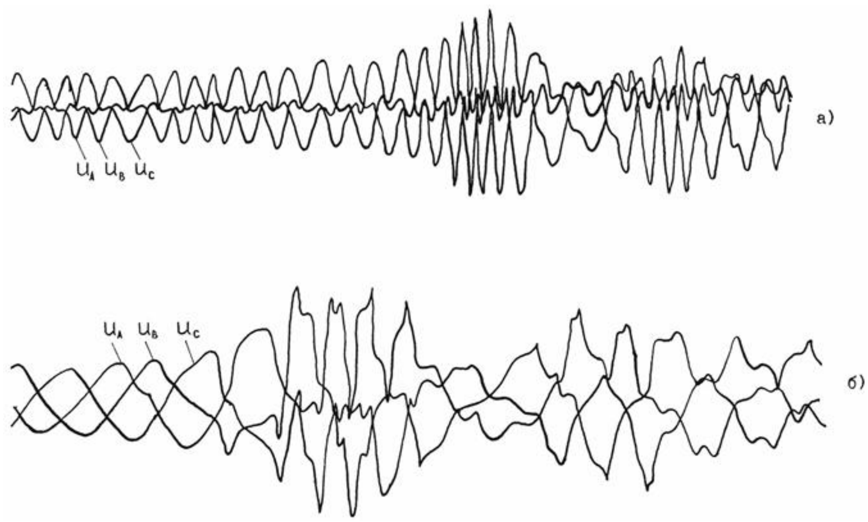

Fig.2. Oscillograms of phase voltages of a three-phase circuit with separate (a) and common (b) magnets in auto parametric oscillation excitation mode.

In the basic frequency oscillation zone of a symmetrical three-phase circuit, no excitation of Raman oscillations can be observed if the active resistances of the windings are rather large.

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A further increase in the input voltage does not significantly increase the voltages of the ferromagnetic elements in each phase. As the applied voltage decreases, the resulting auto parametric oscillations are kept within a sufficiently large input voltage control range, forming a "tightening zone" and then, having reached the maximum amplitude, are compared.
As the experiment shows, the width of the auto parametric oscillation zone depends largely on the value of the longitudinal capacitance C1, C2 and C3. Therefore, by adjusting the capacitance value, the zone of existence of auto parametric oscillations at the fundamental harmonic can be narrowed or widened. Note that in three-phase systems with magnetic coupling between the phases (three-phase P.E. on a single core) the transient time is much shorter than for a system without ferromagnetic coupling Fig. 2. "b", "a".
The proposed classification is mainly determined by the nature and relationship of the linear, non-linear and dissipative elements; the symmetry or asymmetry of the supply voltage and the structure of the element arrangement. Therefore, in accordance with the above-mentioned characteristics, we have divided all three-phase non-linear circuits into the following four classes:
1. three-phase, neutral conductor circuits without magnetic coupling between the phases.
2. Same with neutral conductor with magnetic coupling between the phases.
3 Same without neutral conductor with magnetic coupling between phases.
4 Same without neutral conductor and without magnetic coupling between the phases.
By a three-phase symmetrical non-linear zero conductor circuit without magnetic coupling between the phases we understand a three-phase electrical circuit comprising three non-linear elements, three linear energy-carrying elements and one dissipative element. The presence of a neutral conductor in such circuits creates the conditions for the flow of zero sequence current. If the non-linear elements are star-connected, have a neutral conductor and are connected to the mains via capacitors C1, C2 and C3, the resistances and inductances are not constant over the period. Due to core saturation, the ratio of instantaneous values of magnetic flux and magnetising current varies and with sinusoidal phase-to-phase
In some three-phase circuits with a neutral conductor, peculiar physical processes can occur, associated with the phenomenon of ferroresonance, namely currents (when the phases are symmetrical) or voltages between the phases (when they are not) can change in steps.

III. SCHEMATIC DESIGNS

A three-phase symmetrical non-linear circuit without a neutral conductor should be regarded as a circuit in which there are no zero sequence components in both fluxes and voltages. Therefore, when the windings of the PE are connected in a star arrangement and the line voltage is sinusoidal, the phase voltages will contain harmonics divisible by three, and will not equal the line voltage divided by √3. The magnetising current will therefore contain no harmonic multiples of three, and consequently the magnetic fluxes in all phases will have them. Since the third harmonics of the magnetic fluxes in all three phases coincide, the same electromotive force of triple frequency will be induced in each phase. Linear voltages are equal to the difference of phase voltages or electromotive force and the presence of third harmonic phase voltages is not reflected in them. Accordingly, figures 3-6 show the wiring diagrams.

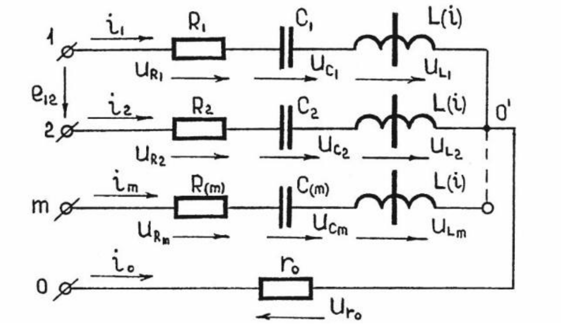

Figure 3. Multi-phase ferroresonant circuit with zero conductor and no ferro-magnetic coupling between the non-linear coils.

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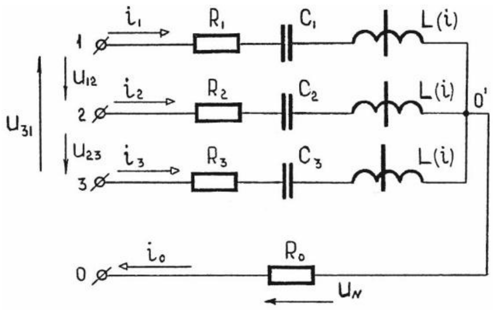

Figure 4. Three-phase ferroresonant circuit with symmetrical power supply.

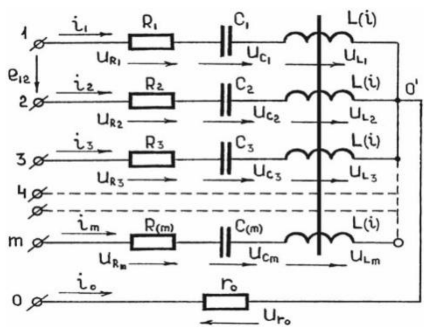

Figure 5.Multi-phase ferroresonant circuit with zero conductor c ferromagnetic coupling between the non-linear coils.

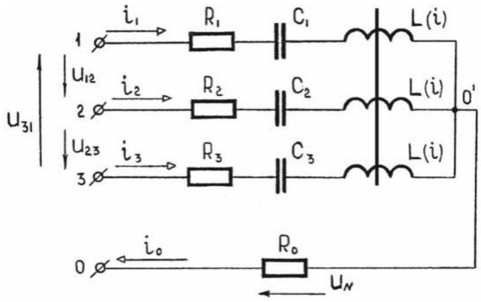

Figure 6.Three-phase ferroresonant circuit with zero-wire c ferromagnetic coupling between the non-linear coils.

In three-phase asymmetrical circuits without a neutral conductor, the same is true if the three phases share a common magnetic circuit. The third harmonics of the magnetic fluxes coincide in phase and induce an electromotive force of this harmonic in the three windings. It should be noted that the third harmonics of the magnetic fluxes in three-phase nonlinear circuits with a coupled magnetic circuit do not reach the same magnitude as the higher harmonics in the currents appear in the case of voltages in each of the phases. If a three-phase star-connected non-linear system has a neutral conductor, even with currents in all three phases symmetrical, the current in the neutral conductor will not be zero, since it consists of uncompensated harmonic currents multiples of three, sometimes much larger than the currents in the individual phases:

$$I0= 3 [I3 + I9 + I15 +...]$$

of the three separate windings, as the third harmonics cannot be short-circuited via the cores and are only short-circuited via the air. When the secondary windings are connected in a delta, there are virtually no third harmonics in the magnetic fluxes.

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VI. CONCLUSION AND FUTURE WORK

Thus, each class of three-phase circuits has its own specific characteristics and it is very difficult to classify them according to their resonance properties. If three-phase circuits are strictly symmetrical, it will be possible to divide them into:

a) series three-phase circuits with ferroresonant voltages which have an "N" shaped volt-current characteristic;

b) parallel circuits with ferroresonant currents which have an "S" shaped volt-current characteristic.