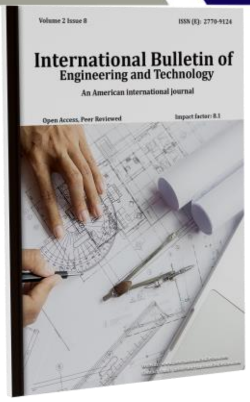

FORMATION OF LOW-FREQUENCY CURRENTS IN FERROMAGNETIC OSCILLATORY CIRCUIT

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Annotation: This article discusses the formation of low-frequency currents in ferromagnetic oscillatory circuits. The harmonic frequencies of the amplitude of the second order of soft excitation are considered for parallel and series connection of multiloop ferroresonant circuits. Each of the circuits (Fig. 1 and Fig. 2) is analyzed, and given the industrial application of frequency converters, it provides an opportunity for further research on the production of frequency converters.
To consider the development of technical processesthe resulting subharmonic oscillations (SHK) are maintained when a source of a higher frequency of energy portions of a periodic change in the parameter of a ferromagnetic element under the influence of a source with a frequency twice the frequency of the output voltage. For this, the primary winding of the proposed transformer serves only for a periodic change in the non-linear parameter, which occurs most intensively when the oscillating circuit is tuned to half the frequency of the power source and the best opportunity is created to maintain and amplify the oscillations that have arisen in the circuit at the SGK frequency and periodically cover active losses, preventing the increase in the amplitude of the SGC.
Keywords: system, serial, winding, magnetic flux, oscillations, frequency, harmonics, transformer, semiconductor, excitation, parameter, amplitude, circuit, current, autoparametric, voltage, source, circuit, non-linearity, equation.

Introduction.

The increase in the consumed energy is associated with the development of civilization, the expansion and deepening of the nonlinear parameter of the circuit, the natural frequency of the oscillatory system, corresponding to the equivalent parameters of the circuit, may be equal to half the frequency of the driving force, and then subharmonic oscillations with large amplitudes are excited in the system [1,2,3,4,5].

experimentalThe study showed that a lot of works are devoted to simple ferromagnetic circuits when excitation of autoparametric oscillation (APC) at a subharmonic frequency (Fig-1., Fig-2.) with one ferromagnetic element or with a nonlinear capacitance: [6,7,8,9,17].L(i)C(u)

It is generally accepted that, in the general case, the frequency (APC) is equal to:

$$\Omega = K * \omega \qquad (1)$$

IBET | Volume 3, Issue 2, February

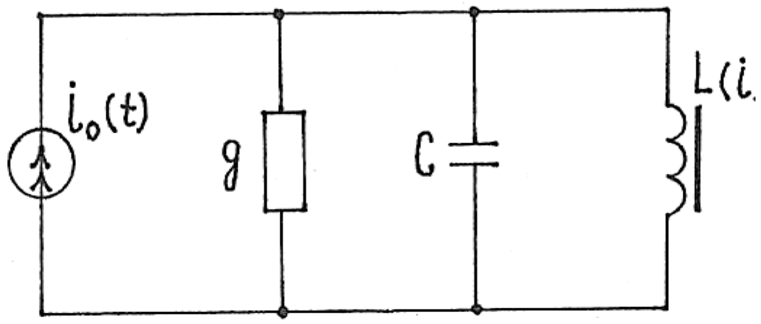

Fig.1. One ferromagnetic element series connection

where is the power supply frequency.ω − AtK = $\frac{1}{2};\frac{1}{3};\frac{1}{5}$ ………… $\frac{1}{n}$
in a ferroresonant circuit hasplace subharmonic resonance, and at etc. polyharmonic resonance, and if , then , and in the circuit there is a resonance at the fundamental harmonic.K = 2; 3K = 1Ω = ω

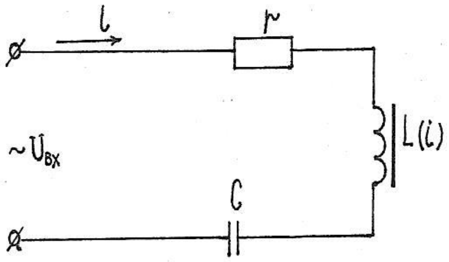

Fig.2. One ferromagnetic element parallel connection

Methods.

It is known that the excitation of a subharmonic oscillation (SHC) in electroferromagnetic oscillatory circuits (EFCC) has a number of specific features and depends on the ratio of the parameters of the circuit and the initial conditions. In some cases, for example, with a smooth change in the input voltage, the SOC mode can switch to a self-oscillating mode with a low frequency, which is a more complex type of nonlinear oscillations[13,14,15].

Any oscillatory system is potentially self-oscillatory, because even in the absence of any, almost always occurring, random inductions or charges (power lines, atmospheric discharges), there are always certain initial conditions that can cause excitation of autoparametric oscillations due to accumulated charges or random inductions. In this case, the frequency of excited oscillations is a multiple number of times less than the frequency of parameter changes [1;6;11].

In the circuits of the second group, the excitation of the SGC does not depend on the value of the initial charge on the capacitor, although the phase and amplitude of the input voltage and the magnitude of the bias current affect the excitation process[7,8].

One of the classic circuits for excitation of the second-order SGK is the so-called balanced circuit (Fig. 3.), Consisting of two identical transformers A and B, the primary windings of which are connected in series and in accordance, and the secondary windings are in series and counter. The bias winding is turned on in such a way that the magnetic flux generated by it is added to the magnetic flux in the core of transformer A and is subtracted from the magnetic flux in the core B of the second transformer. To excite the APC at the SGK frequency, a capacitance must be connected to the output of the "a-b" circuit.$W_1 W_2 W_0 C$

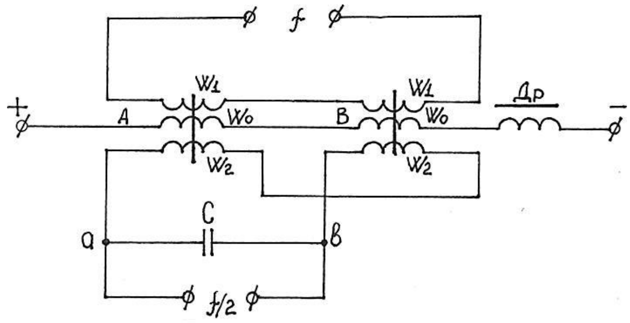

Fig.3. The balance scheme of the SGC of the second order

The magnetizing forces for each of the transformers will be equal to:

$$F_A = I_0 * W_0 + I_1 * W_1 \quad ;) F_B = I_0 * W_0 - I_1 * W_1. \qquad (2)$$

As a result, the weber ampere characteristic of an individual transformer becomes unbalanced. Generally speaking, the total voltage of the fundamental frequency at the output terminals "a-b" is zero, since the voltage on the windings at this frequency is shifted by 180 electrical degrees. However, these output terminals "a-b" may be energized as a result of excitation of autoparametric oscillations. Here, such phase-frequency relationships are created between the components of the fundamental harmonic and the SOC that the output circuit and the pump circuit are "decoupled" in frequency.W_2[9,10,11]

The resulting SGC are supported due to the receipt from the source of a higher frequency of portions of energy with a frequency that is a multiple of the frequency of the output voltage. This is due to a periodic change in the parameter of the ferromagnetic element under the influence of a source with a frequency twice the frequency of the output voltage. The primary winding of this transformer therefore only serves to periodically change the non-linear parameter, which occurs most intensively when the circuit is tuned to half the frequency of the power source.

Due to this, the best opportunity is created to maintain and amplify the oscillations that have arisen in the circuit at the SGK frequency. The perturbing force acts on such oscillations, periodically covering the active losses that prevent the increase in the amplitude of the SGC[12].

The main advantage of the parameters is their speed, i.e. relatively short transition time from one phase state to another, based on the use of semiconductor elements. This, in turn, served as the basis for the creation of super-high-speed electronic computers.

The processes in power ferromagnetic frequency dividers are of the same nature as the parameters. However, the use of autoparametric circuits with semiconductor elements in the power frequency divider mode has not found practical application due to the relative smallness of the capacitance of the pn junction.

One of the advantages of existing semiconductor frequency dividers is the ability to change the frequency over a wide range. Despite this, their use to obtain lower frequencies is impractical due to the complexity of the control circuit and insufficient overload capacity. In such cases, it is more rational to use ferromagnetic frequency dividers, as they are easier to manufacture and operate.

Multiloop ferroresonant circuits compare favorably with single-loop ones by the multistability of phase states and the ability to provide stable APC at dominant frequencies. From the point of view of creating specific schemes for converting the frequency and number of phases, they are of great theoretical and practical interest. Since they allow to realize those properties of ferroresonance converters that distinguish them favorably from thyristors, namely: ease of execution and increased reliability in operation, a significant improvement in the shape of the output voltage curve, the possibility of simultaneous frequency conversion and the number of phases.

Results.

Another problem that multi-circuit ferroresonant circuits can solve is the conversion of the number of phases to power a multi-phase load with a non-standard frequency current from a single-phase source. In this case, the specified phase distribution in ferroresonant converters does not depend on the load parameters.

The problem of obtaining a multi-phase voltage source by a frequency source is solved either by grouping single-phase ferroresonant circuits connected in series or in parallel, or by means of multi-phase transformers.

Three-phase output converters known to us from classical literature can be divided into two types. The first type is a ferromagnetic frequency converter (FFC) that performs both frequency conversion and the number of phases [5,7].

The principle of frequency conversion in both cases is based on the excitation of autoparametric oscillations in the EPMCC at the subharmonic frequency. A feature of such multi-circuit ferroresonant circuits is the mutual biasing effect of one phase on another, as a result of which a component of the magnetic field appears in each of the cores. This scheme assumes the presence of an automatic starting device (APU) to provide a given value of the initial phase of the applied voltage during excitation of the APC and stabilization of the phase sequence.

The second type of circuit includes a ferroresonant circuit, which has become classical and is called "balanced". The circuit in fig-3, used as a frequency divider by half, consists of two identical transformersA and B linear capacitor C.

However, if the secondary winding of this circuit is conditionally considered as a two-circuit circuit, the linear capacitance is divided, which together with the nonlinear inductances of transformers A and B forms two ferroresonant circuits, then here we are dealing with frequency division, accompanied by a simultaneous multiplication of the number of phases in the same multiplicity (Fig. -4, a) i.e. we get here in these circuits a frequency division by half, and the voltage of the SGC and are shifted relative to each other by 180 electrical degrees. $U_{a0}U_{B0}$

IBET | Volume 3, Issue 2, February

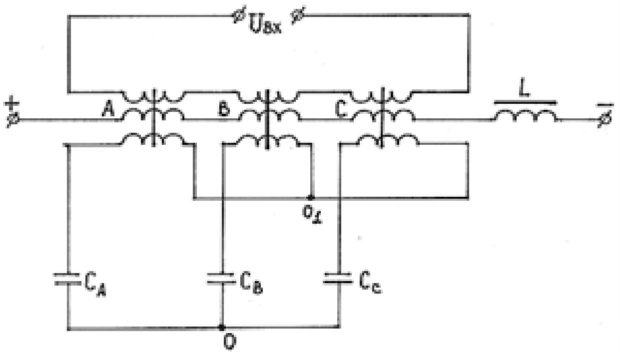

Fig.4 (a). Two parallel-connected ferroresonant oscillatory circuit

In order to further study multi-circuit EPMCC, from the point of view of excitation of APC in them at the frequency of the second and third order SOC, in the presence of a bias winding to the circuit of two parallel-connected ferroresonant oscillatory circuits, we connect another circuit and bring it to the form shown in (Fig. -4, c).

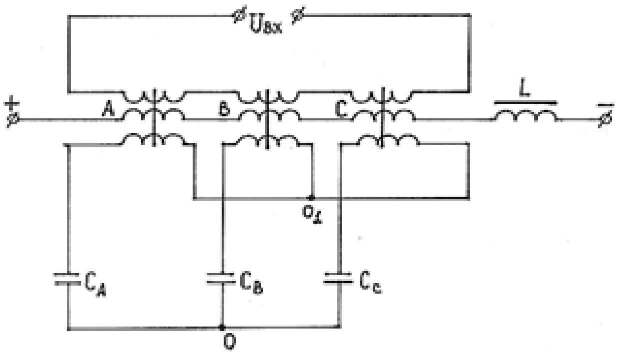

Fig.4 (c) Three ferroresonant oscillators connected in parallel circuit.

Multiloop ferroresonant circuits also include three-phase circuits in which APCs occur. APC excitation processesthree-phase circuits are studied in sufficient detail[1,4,7,8]. In these works, an analysis of stationary regimes was carried out using truncated Duffing equations. This made it possible to determine the influence of various factors on the mode of excitation and existence of the SGC under three-phase action on the ferroresonant circuit. However, in this case, the interaction of phase relations between the input voltages and the SHC, as well as the conditions for ensuring the unambiguity of the phase states and the symmetry of the output voltages in amplitude, remained unclear.

Disscusion.

The excitation of the APC of a particular frequency, the amplitude and phase relationships in a three-phase circuit is determined by the phase states of each of the ferroresonant circuits. When the APC is excited in one of the three parallel ferroresonant circuits (Fig. 5), the remaining two circuits are drawn into oscillations.

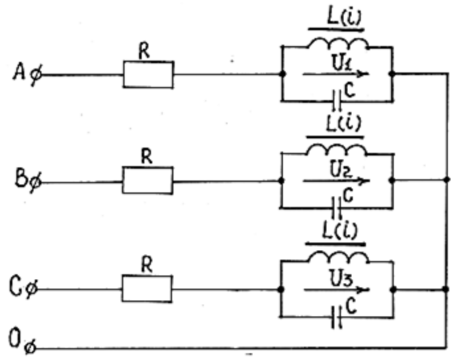

Fig.5. Three parallel ferroresonant circuit

In this case, the equilibrium equations between input voltages and voltages in ferroresonant circuits are also ambiguous. In the general case, in a three-phase system, phase shifts between third-order SGC voltages can be established in three ways:$U_{AB}, U_{BC}, U_{CA} U_1, U_2, U_3$

$$\frac{2\pi}{3} \quad \frac{4\pi}{3} \quad \frac{6\pi}{3} \qquad (3)$$

Studies of the conditions for excitation and stable maintenance of APC in multiphase circuits have shown that some features, in particular, those associated with phase relationships between APC and a power source, make it possible to create multi-stable elements and devices with discrete phase properties that can be applied in various fields of technology. One of the important features of multiphase systems is also that the number of phase states increases with
an increase in the order of the subharmonic.

Conclusion.
Thus, there are several phase states, udov The allowable values of the phase and linear voltages at the frequency of the SGC, that is, the phase states of the SGC in each of the ferroresonant circuit determines the amplitude of the oscillations that occur at one or another harmonic. As a result, it can be noted that this methodshould be carefully studied, analyzed and appropriate conclusions drawn in order to ensure reliable and economical operationconverter technology.

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