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Ferromagnetic and Ferroelectric Transformers

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FERROMAGNETICANDFERROELECTRICTRANSFORMERS

Ferromagnetic and Ferroelectric Transformers

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I. Introduction

In the technology the transformers with the ferromagnetic cores widely are used [1-7]. The possibility of the energy transfer of one winding to another without the presence of galvanic contact between them is the special feature of the work of any transformer. Moreover the nearer are located the turns of primary and secondary windings, the greater the coupling coefficient between the windings. If the discussion deals with the transformer without the presence of the magnetic core, then ideal version is that case, when windings are wound by the bifilar method, when the windings, which present primary and secondary windings, it hurries about into two wires. The coils of the wire of windings are located maximally closely with this method, that also gives the possibility to obtain maximum coupling coefficient. The windings, raspolozhenye on the common ferromagnetic core, also have very high coupling coefficient; however, in the existing literature there is no description of physics of the work of transformers with this core.

Is well known the experimental fact, which indicates that the presence of ferromagnetic core in the coil essentially increases its inductance. But physics of this process is nowhere described.

A large drawback in the transformers with the ferromagnetic cores is the fact that they cannot work at the high frequencies. This is connected with the large inertness of the process of the reversal of polarity of ferromagnetic material.

In the article physics of the work of transformer with the ferromagnetic core is examined.

Is examined also the new type of transformers with the ferroelectric core. The merit of such transformers is the fact that they can work at the very high frequencies.

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II. Physics of the Work of Transformer with the Ferromagnetic Core

If current flows along the coil or the separate wire, then the energy, accumulated in their inductance, is determined by the relationship

$$W_L = \frac{1}{2} L I^2$$

The inductance of wire, along which flows the current, they connect with the presence around this wire of magnetic pour on and since magnetic fields they possess the specific energy

$$W_{0H} = \frac{1}{2} \mu H^2 ,$$

their integration for the volume, occupied by fields, also gives the energy

$$W_H = \frac{1}{2} \mu \int_V H^2 dV .$$

It is obvious that

$$W_L = W_H .$$

But the magnetic fields, which surround conductor, depend on current; therefore inductance is the coefficient, which connects the energy, accumulated in this conductor, the current in it current. Until now we always connected this inductance with the magnetic fields, which surround the conductor in question. But there is another mechanism of loading of the conductor, when inductance depends not only on its configuration and those magnetic pour on, which this conductor surround (Figure 1)

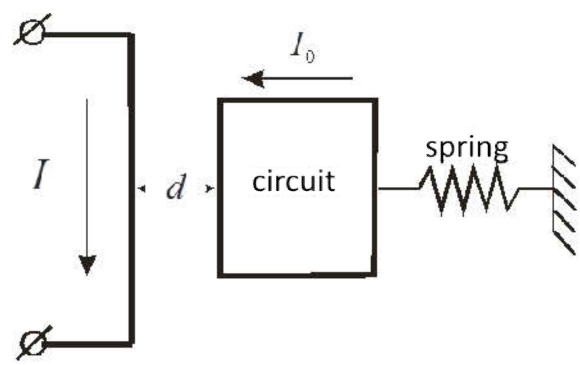

Figure. 1: Outline with the frozen current near the conductor, along which flows the current

Let us assume that we have the superconductive outline, in which is frozen the current I_0 located at a distance d from the conductor, along which flows the current I. Outline with the frozen current is fixed with the aid of the spring to the rigid base. If we carry the current through conductor, then outline with the frozen current will begin to it to be attracted, extending spring and thus, stocking in the spring energy. Moreover, the greater the current in the outline will be, the stronger it will be attracted to the wire, and the greater the energy will be accumulated in the spring. Therefore with one and the same values of current in the conductor, the energy, spent for the tension of spring, will be different and there will be it to zavisettakzhe, also, from the current in the short-circuited outline. The system examined is equivalent to inductance with the only difference that energy in this inductance will be equivalent accumulated not in the magnetic field, but in the spring. Moreover inductance in this case will depend also on the distance between the outline and the conductor, and from the current, which flows along the conductor also of the current, frozen in the outline. The characteristic property of the system examined is the fact that the approximation of outline with the frozen current to the wire, along which flows the current, will lead to the excitation it the currents, opposite to initial current. Thus, the resulting current will prove to be less than that current, which would take place in the absence of outline with the frozen current. This behavior of summed current testifies about loading of wire, along which flows the current.

It is possible to present another type of this system. For this it is necessary outline with the frozen current to place on the axis, which passes, through its center, and to the axis to fasten the helical spring, which ensures the steady state of outline in the situation, when its conductors are exist equidistantlyed from the conductors of outer ducts (Figure 2) Then with the flow of the current through conductor outline with the frozen current will be turned in that or other side, turning helical spring. In this case in the spring the energy will be accumulated, and the direction of the twisting of spring will depend on direction of flow in the conductor. Specifically, this specific form of inductance works with interaction of conductors with the current with the magnetic materials.

Until to the ferromagnetic material is superimposed strange external magnetic field, its atoms or the molecules, which represent the microscopic of outline by the szamorozhennym current, they be in the disordered state. This state appears for them it is equilibrium. But external field as soon as is superimposed on the ferromagnetic material, begins to occur their orientation, similar to that, which is depicted in Figure 1. To the realization of the process of deviation from the state of equilibrium the energy, which presents inductive energy of conductor with the current, is expended. Moreover, as it was already said, the distance between conductor itself and ferromagnetic material can be different, and it depends on the strength of microscopic frozen currents.

If the current, which flows through conductor, is variable, then the process examined is reactive. In this case the atoms or the molecules, which represent of outline with the current, accomplish rotational-vibrational motion and the energy, accumulated in the spring, alternately that

Let us examine the process, with which the magnetic core ensures high coupling coefficient between that removed by conductors, transferring thus energy of one conductor in another.

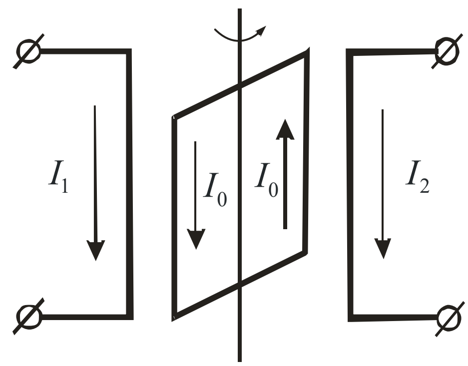

Figure 2: Transfer of the currents of induction of one conductor in another with the presence between them of ferromagnetic material

If in the core circuit current increases, then the conductor of this outline begins to attract to itself the conductor of turn with the frozen current. The rotation of turn leads to the fact that its opposite side begins to approach a conductor of second outline, inducing in it the current of induction. If second outline is extended, and energy in it is not expended, thus it does not influence processes in this system. But if second outline is loaded to the effective resistance, then the turning of outline with the frozen current requires the expenditure of active energy. This turning achieves the core circuit, from which this energy takes away. This leads to the fact that the core circuit for the power source is converted from the purely inductive load into the load, in which will be present the active component. This active component will be determined by voltage drop across the terminals of second outline and by resistance to them of that connected.

If there are two coils, located on the general magnetic core, then the primary coil, into which is introduced the current, the synchronous turning of all microscopic outlines with the frozen current is achieved. The addition of the currents of these outlines leads to the formation of macroscopic current inside the ferromagnetic material, which according to the diagram,

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depicted in Figure 2, it interacts with the conductors also of primary, and second outline. This property of ferromagnetic material ensures the energy transfer from the primary winding to the second. In the case, when energy in the secondary winding is not consumed ferromagnetic material only increases primary inductance.

III. Ferroelectric Transformers

In connection with the fact that the law of magnetoelectric and electromagnetic induction, recorded in the total derivatives [8], they are symmetrical

$$\oint \vec{E}' d\,\vec{l}' = -\int \frac{\partial \vec{B}}{\partial t} d\,S - \oint [\vec{B} \times \vec{V}] d\,\vec{l}'$$

$$\oint \vec{H}' d\,\vec{l}' = \int \frac{\partial \vec{D}}{\partial t} d\,S + \oint [\vec{D} \times \vec{V}] d\,\vec{l}' \quad ,$$

therefore must exist and the symmetrical technical solutions. Such solutions exist. For example, with the aid of the revolving magnetic field it is possible to create electric motors. For the same purposes it is possible to use the revolving electric field, and the engines, which use this principle, exist. There exists the transformers c ferromagnetic [serdechnikkom], in which with the aid of the magnetic flux they transfer energy of one winding into another. The symmetry of the laws indicated tells us, that must exist the transformer, whose core will be executed not of the ferromagnetic material, but of the ferroelectric. In the technology the transformers with the ferromagnetic cores widely are used. Their incapacity to work at the high frequencies is a large drawback in such transformers. Is connected this with the large inertness of the processes of the reversal of polarity of transformer core. And in this connection question arises, and is it possible to create the transformer, in which as the core is used not the ferromagnetic material, but ferroelectric. Since the processes of electrical polarization have very small inertia, this transformer could work at the very high frequencies.

Let us examine the schematics of ferroelectric transformers [9,10]

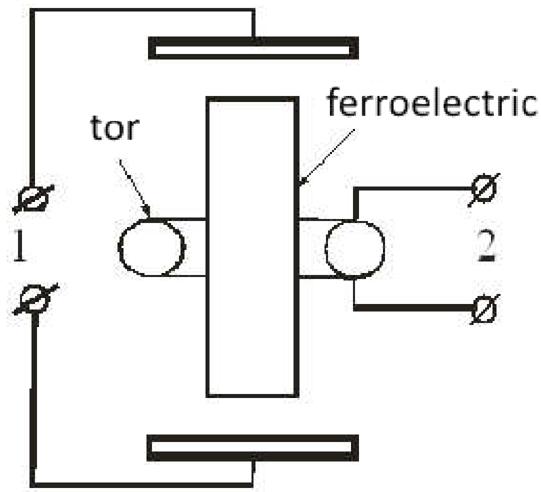

Figure 3: Schematic of ferroelectric transformer

Into the composition of transformer enters the parallel-plate capacitor, between plates of which is placed the cylinder from the ferroelectric with the large dielectric constant. On the cylinder is placed the winding of torus, whose ends are connected to terminals 2. During the supplying to the capacitor of alternating voltage in the cylinder there will be leak polarization currents and the time-varying circulation of magnetic field will arise around the cylinder. This circulation will excite in the torus-shaped winding currents and a variable potential difference will appear on terminals 2.

Transformer with the toroidal ferroelectric core is depicted in Figure 4.

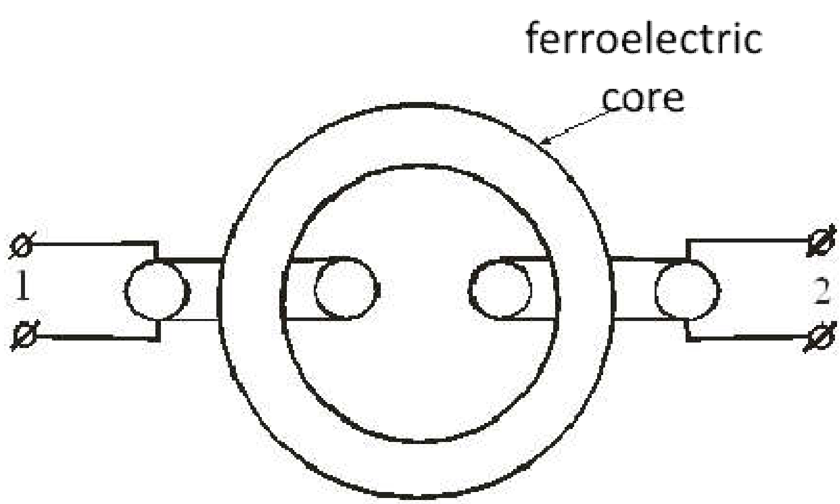

Figure 4: Transformer with the toroidal ferroelectric core

It consists of the torus-shaped core, made from the ferroelectric, on which are placed two torus-shaped windings. The transformation ratio of this transformer depends on the relationship of the number of turns in the windings. The merit of ferroelectric transformers is the fact that they can work at the very high frequencies.

IV. Conclusion

In the article is examined physics of the work of transformer with the ferromagnetic cores and trasformatorov with the ferroelectric cores. In spite of simplicity both ideas and constructions transformers and amplifiers with the ferroelectric cores before the appearance of works [9,10] are nowhere described. But indeed they open very large prospects. It is known that the magnetic amplifiers, which possess high reliability, cannot find wide application only because they work at the low frequencies. In this case there are no such limitations in practice, since the processes of electrical polarization have very small inertia, and, using the transformer examined, it is possible to create the reliable wideband amplifiers, which work at the very high frequencies.

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