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STATIC DESCRIPTIONS OF A THREE-PHASE TRANSFORMER TAKEN INTO ACCOUNT OF SENSITIVE ELEMENTS

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ABSTRACT

The article analyzes the principles of constructing converters that convert the magnitude of primary currents when controlling and regulating the reactive power of the power supply system into an output signal in the form of voltage. The dependence of the appearance of output voltage on various parameters of a distributed parametric, three-phase, three-sensitive converter has been studied.

Key words

reactive power, suitable sensing element, electromagnetic current, input windings, magnetic resistance, primary windings, current frequency.

Providing consumers with high-quality electricity depends on such parameters as the wide functionality of monitoring and control systems, high sensitivity of devices, operational reliability and data accuracy. Therefore, special attention is paid to the development and application of primary measurement and conversion elements, principles of their construction, research algorithms and software, a wide functional range of signal measurement and conversion tools. In this regard, it is important to create and implement a wide range of functional types of measuring and changing elements for monitoring and controlling reactive power in power supply systems of developed countries.

A number of scientific studies are being carried out aimed at improving the elements and means of control and monitoring devices for reactive power, as well as power supply systems based on them. In this direction, one of the main requirements is to provide high-quality signals to monitoring and control devices about the magnitude and parameters of reactive power of electricity. That is why it is important to control and manage reactive power sources in power supply, monitoring, planning, scheduling and managing various converters and processes in their structures based on rational algorithms.

The static characteristics of transformers that convert the magnitude of primary currents into an output signal in the form of voltage when controlling and monitoring the reactive power of the power supply system are analyzed. The

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dependence of the output voltage (Uechiq signal) on various parameters of the distributed parameter of a three-phase converter with three sensitive elements has been studied [2]. A three-phase converter with three sensitive elements and a circuit for converting primary currents into secondary voltage will look like Fig. 1.

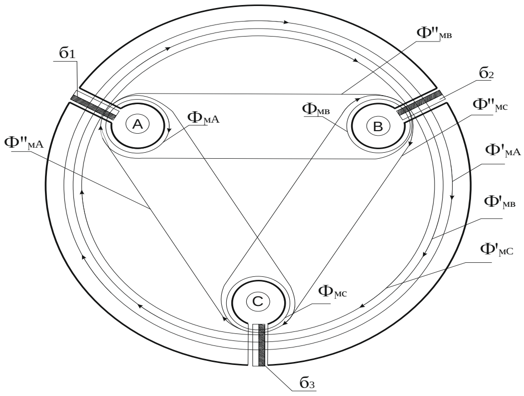

Fig. 1. Three-phase converter with three sensitive elements.

In this case: $\Phi_{\mu A}$, $\Phi_{\mu B}$, $\Phi_{\mu C}$ – A,B,C - The main magnetic currents generated by the phase currents of the electrical network and crossing the sensitive element corresponding to the phase.

$\Phi'\mu_{A}$, $\Phi'_{\mu B}$, $\Phi'_{\mu C}$, $\Phi''\mu_{A}$, $\Phi''_{\mu B}$, $\Phi''_{\mu C}$ - Magnetic currents created by non-main phase currents for the sensitive element.

The voltages (signals) generated in the secondary circuit of a three-phase transformer with three sensitive elements are expressed by the following expressions:

$$U_a = 4.44 f w_{1ч}\left(\frac{w_{1k}}{R_{\mu 1\varepsilon}+R_{\mu\delta 1\varepsilon}} I_A + \frac{w_{2k}}{R_{\mu 1\varepsilon}+R_{\mu 2\varepsilon}+R_{\mu\delta 1\varepsilon}+R_{\mu\delta 2\varepsilon}} I_B + \frac{w_{3k}}{R_{\mu 1\varepsilon}+R_{\mu 3\varepsilon}+R_{\mu\delta 1\varepsilon}+R_{\mu\delta 3\varepsilon}} I_C\right);$$

$$U_B=4.44 f w_{2ч}\left(\frac{w_{1k}}{R_{\mu 1\varepsilon}+R_{\mu 2\varepsilon}+R_{\mu\delta 1\varepsilon}+R_{\mu\delta 2\varepsilon}} I_A+\frac{w_{2k}}{R_{\mu 2\varepsilon}+R_{\mu\delta 2\varepsilon}} I_B+\frac{w_{3k}}{R_{\mu 2\varepsilon}+R_{\mu 3\varepsilon}+R_{\mu\delta 2\varepsilon}+R_{\mu\delta 3\varepsilon}} I_C\right);$$

$$U_C=4.44 f w_{3ч}\left(\frac{w_{1k}}{R_{\mu 1\varepsilon}+R_{\mu 3\varepsilon}+R_{\mu\delta 1\varepsilon}+R_{\mu\delta 3\varepsilon}} I_A+\frac{w_{2k}}{R_{\mu 2\varepsilon}+R_{\mu 3\varepsilon}+R_{\mu\delta 2\varepsilon}+R_{\mu\delta 2\varepsilon}} I_B+\frac{w_{3k}}{R_{\mu 3\varepsilon}+R_{\mu\delta 3\varepsilon}} I_C\right);$$

f- frequency of electric current;

$W_{1к}$, $W_{2к}$, $W_{3к}$ – number of input coil windings;

$W_{1ч}$, $W_{2ч}$, $W_{3ч}$ – number of coil windings of sensitive elements;

$R_{\mu 1\Sigma}$, $R_{\mu 2\Sigma}$, $R_{\mu 3\Sigma}$, $R_{\mu\delta 1\Sigma}$, $R_{\mu\delta 2\Sigma}$, $R_{\mu\delta 3\Sigma}$,- I_A, I_B, I_C - primary currents Ф'μ1, Ф'μ2, magnetic circuit and air gaps δ1, δ2, δ3 magnetic resistance of the flux path from. Their values are determined based on the distributed parameter model:

$R_\mu = p_\mu * L_\mu / F = L_\mu / \mu F$, $\quad R_{\mu\delta} = p_{\mu\delta} * \delta / F = \delta / \mu_o F$

p_μ, $p_{\mu\delta}$ - material of the magnetic circuit and relative magnetic resistance (absorbing capacity) of the air spaces in which the sensitive element is located [2].

In this model, the main variables are I_A, I_B, I_C - primary currents (in the range of 1-500 amperes). W1k, W2k, W3k input coils number of coils (1-5) number of coils,

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$W_{1ч}$, $W_{2ч}$, $W_{3ч}$ - sensitive elements (coils) output coils number of windings $W_{1к}$, $W_{2к}$, $W_{3к}$ =(20-200) winding change in the range Rμ1∑,Rμ2∑ Rμ3∑, Rμδ1∑, Rμδ2∑, Rμδ3∑ magnetic resistance parts of the change Lμ, the values of μ, μo, the length of the gap forming the magnetic resistance, and the cross-sectional surface Fμ were changed, studies were carried out based on the above model [2].

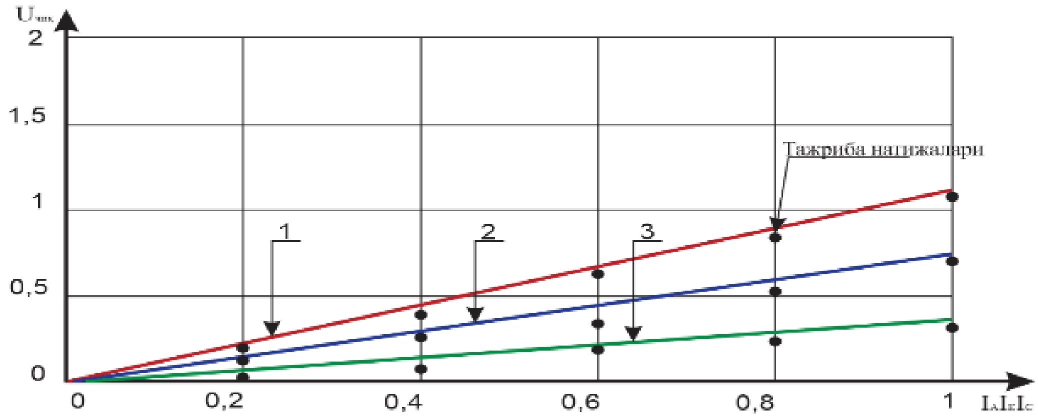

Fig-2. Graph of the dependence of the output (flight) voltage of the converter on the number of primary windings.

A graph of the output voltage depending on the number of primary windings for the case when the number of primary windings of the converter is equal to W1= 1(3), W1= 2(2), W1= 3,(1) , and the number of secondary windings is equal to W_2=100, shown in rice. 2. Here primary currents I_1=0.2-1 A, network frequency F= 50 Hz, active surface of the sensitive element F_{coil}= 0.0001 м², $F_{stel\ core}$=0.0004 м², $L_{stel\ core}$=0.05 м, length of the steel core and air gap L_x= 0.001 m.

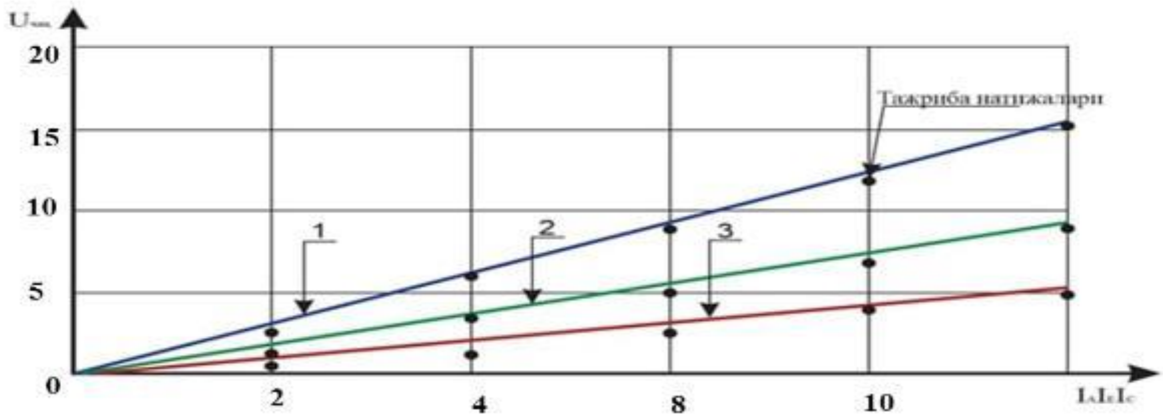

Fig-3. Graph of the dependence of the output (flat) voltage on the number of primary windings.

With the number of primary windings of the transformer equal to W1=2(3), W1=3(2), W1=5(1), and the number of secondary windings W_2=100, the graph The dependence of the output (U_{out}) voltage on the number of primary windings is shown in the figure 3. In this case, primary currents I_1=0.2-10 A, network frequency F = 50 Hz, active surface of the sensitive element F_{coil}= 0.002 м², F_{coil}=0.004 м², $L_{coil\ core}$=0.01 м, steel core length, air gap L_x= 0.001.

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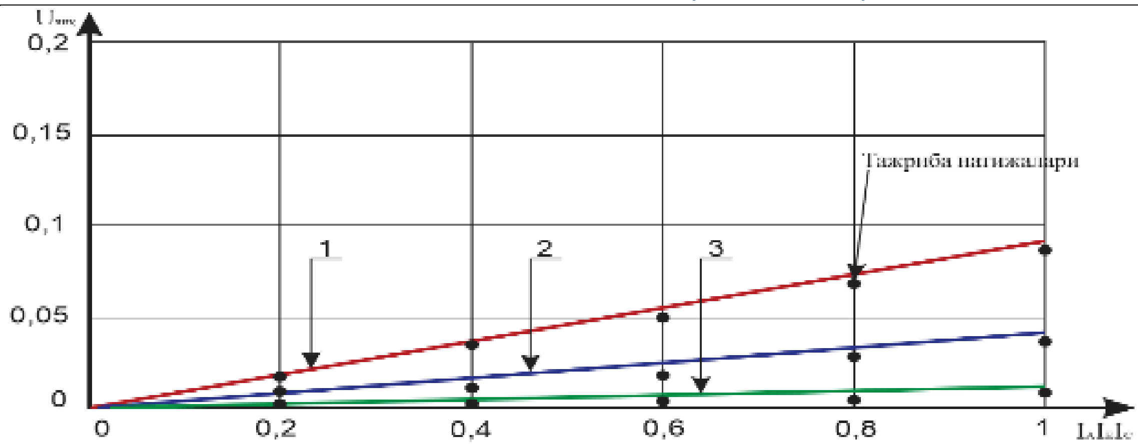

Fig-4. Graph of the dependence of the output voltage (U_{out}) on various sizes of the surface of the steel core (F_{steel}) for the case when the number of primary windings of the transformer is W_1= 1, and the number of secondary windings is up to W_2=200.

On this graph (Fig. 4) primary currents I_1 = 0.2-1 A, mains current frequency F = 50 Hz, active surface of the sensing element F_{coil}= 0.0001 m2, steel core length $L_{stel\ core}$= 0.05 m, air gap L_x = 0.001 m. The surface of the steel core has different sizes: F_{coil}=0.0001 m2 (green-1), F_{coil}=0.0004 m2 (blue-2), F_{coil}=0.0009 m2 (red-3).

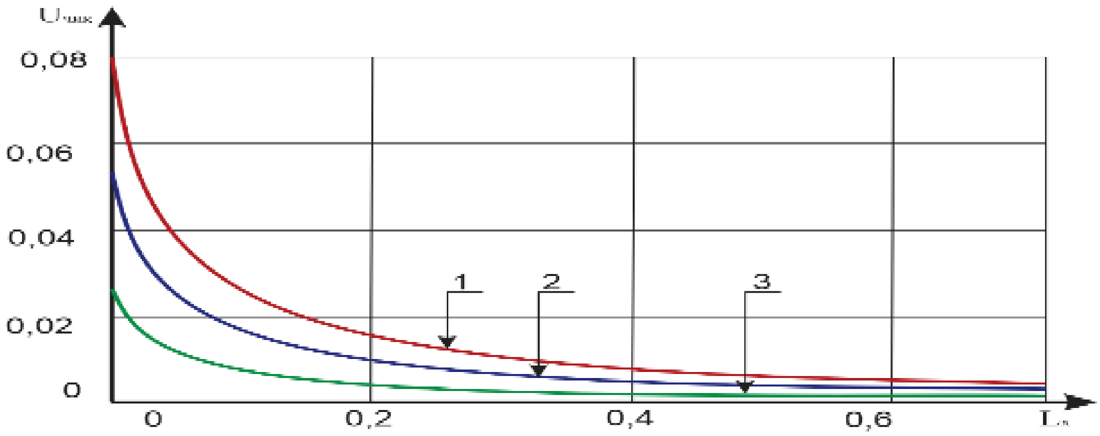

Fig-5. Graph of the dependence of the output (U_{out}) voltage of the converter on the size of the air gap (L_x).

In the graph above (Fig. 5), the number of primary coils W_1= 2, the number of secondary coils W_2=200, primary currents I_1=100 A (3), I_1=200 A (2), I_1=300 A (1) are described. In this case, the network frequency f = 50 Hz, the active surface of the sensitive element F_{coil}= 0.0001 m2, the active surface of the steel core F_{coil}= 0.0004 m2, the magnetic flux path length of the steel core $L_{coil\ core}$= 0.05 m are equal to the values of [2].

According to the graph of the dependence of the output voltage on the number of primary windings, the number of primary windings of the converter is W_1= 2(3), W_1= 5(2), W_1= 3, the case when the number of secondary windings is W_2=20 for:

$\Delta U\%=| U_x - U_T | / U_T *100\%=|1{,}08-1{,}05| /1{,}05*100=2.86\ \%$

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Three-phase, three-sensitive elements, electromagnetic current-voltage converters have theoretically calculated values in the distributed parameters model, compared with the values calculated in the real model, the difference in adequacy indicators is 2.86%.

The static description of the converter during the transition from the conversion coefficients $K[\Phi_{\mu g}(x),U_{э2}]$ и $W[\Phi_{\mu}(0),\Phi_{\mu g}],\Phi\mu g]$ to normal physical quantities when controlling reactive power sources of power supply systems is expressed in the following form:

$$U_{Э2} = 2\cdot\pi\cdot f\cdot I_{э1}\cdot w_{ов}\cdot w_{пио}\cdot\int_{0}^{l_{x.o}}\Phi_{\mu g}(x)\cdot dx\,,$$

f – primary current frequency; $I_{э1}$ is the value of the primary input current;

$w_{СЭ}$ - number of windings of the sensitive element; $w_{ов}$ - number of turns of the primary element; $l_{x.o}$– height of the air gap; $\Phi_{\mu g}(x)$-magnetic flux.

Conclusions and offers

Based on the results of the study of models with distributed parameters, it can be concluded that static and dynamic models of three-phase three-sensitive electromagnetic current-to-voltage converters have sensitive elements of size L_x = 0.0003-0.001 m when placed in the air gap and on the surfaces of the sensitive elements F_{coil}= 0.002 m2 , F_{coil}= 0.004 m2, length of the steel core $L_{coil\ core}$= 0.01 m. Moreover, the standard value of the output voltage (20 V) is provided with the number of secondary windings W_2 = 100.

From the results of calculations of models with distributed parameters, we can conclude that with an increase in the value of the air gap (L_x), the value of the output signal in the form of voltage (U_{out}) decreases sharply, an increase in the number of windings, the number of sensitive elements has a direct effect on the change in the value of the output signal, and a change in the cross section sensing elements causes the output signal in the form of a signal to provide a linear voltage change.

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