Static Descriptions of Three-Phase, Three-Sensitive Element Transmitter

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ABSTRACT

The article analyzes the structural principles of the converters that convert the value of the primary currents in the control and control of the reactive power of the power supply system to the output signal in the form of voltage. The dependence of the appearance of the output voltage on the different parameters of the distributed parametric, three-phase, three-sensing element converter has been studied.

Keywords: Reactive power, suitable sensing element, electromagnetic current, input windings, magnetic resistance, primary windings, current frequency.

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

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

The static characteristics of the transformers, which change the value of the primary currents into the output signal in the form of voltage, were analyzed in the management and control of the reactive power of the power supply system. The dependence of the value of the output voltage (U_{out} signal) on various parameters of a distributed parameter, three-phase, three-sensing element converter has been studied [2]. A three-phase, three-sensing element converter and a scheme for converting primary currents to secondary voltage will have the appearance of Fig. 1.

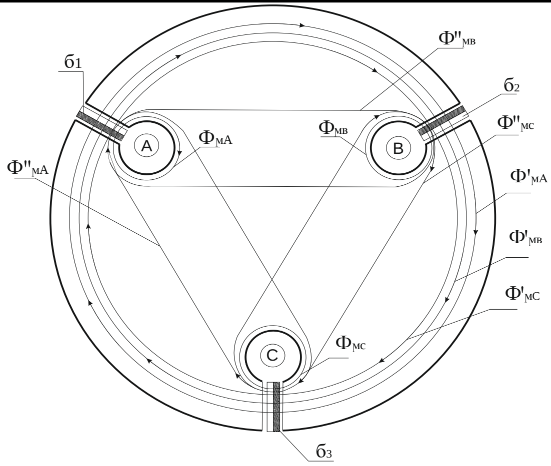

Figure 1. three-phase three-sensing element converter.

Here: $\Phi_{\mu A}$, $\Phi_{\mu B}$, $\Phi_{\mu C}$ -A,B,C- The main magnetic currents produced by the phase currents of the electric network and passing through 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 generated by non-main phase currents for the sensitive element.

The voltages (signals) generated in the secondary winding of a three-phase, three-sensitive element transformer are expressed by the following expressions:

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

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

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

Where: f-frequency of electric current;

W_{1k}, W_{2k}, W_{3k}-number of windings of input coils;

W_{1ch}, W_{2ch}, W_{3ch} are the number of windings of the coils 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 $F'_{\mu 1}$, $F'_{\mu 2}$, $F'_{\mu 3}$ magnetic core and air gaps δ1, δ2, δ3 the magnetic resistance of the flux path from d3. Their values are determined based on the distributed parameter model:

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

where: p_μ, $p_{\mu\delta}$ - relative magnetic resistances (absorbabilities) of the magnetic core material and the air gaps where the sensitive element is placed

I_A, I_V, I_S-primary currents (in the range of 1-500 amperes) as the main variables in the given model. W_{1k}, W_{2k}, W_{3k}-input windings number of windings (1-5) number of windings, W_{1ch}, W_{2ch}, W_{3ch}-sensitive elements (windings) output windings, number of windings W_{1k}, W_{2k}, W_{3k} =(20-200) the winding is changed to range $R\mu 1\Sigma$,$R\mu 2\Sigma$ $R\mu 3\Sigma$, $R\mu\delta 1\Sigma$, $R\mu\delta 2\Sigma$, $R\mu\delta 3\Sigma$ magnetic resistances of the change parts μ, μo values Lμ, of the interval that formed the magnetic resistance researches were conducted based on the above model, changing the length of the piece and the cross-sectional area F_μ.

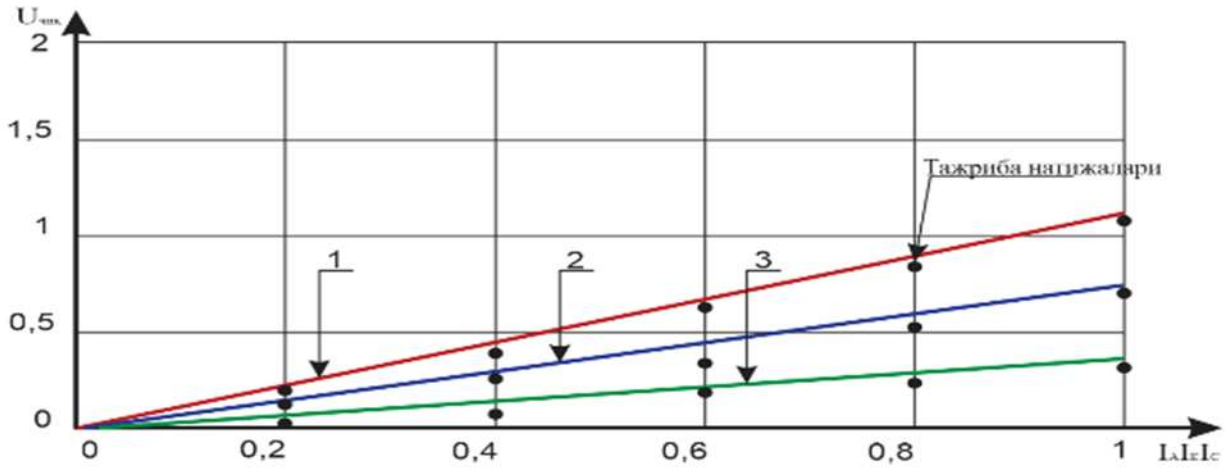

Figure 2. The graph of the dependence of the converter output (Flight) voltage value on the number of primary windings.

When the number of primary windings of the converter is equal to W_1= 1(3), W_1= 2(2), W_1= 3,(1), the graph of the dependence of the output voltage on the number of primary windings for the case when the number of secondary windings is equal to W_2=100 is shown in Fig. 2 given Here, primary currents I_1=0.2-1 A, Network frequency F= 50 H_z, sensitive element active surface F_{circ}= 0.0001 m2, F_{steel} =0.0004 m_2, Lsteel core =0.05 m steel core length, and air gap L_x= 0.001 m.

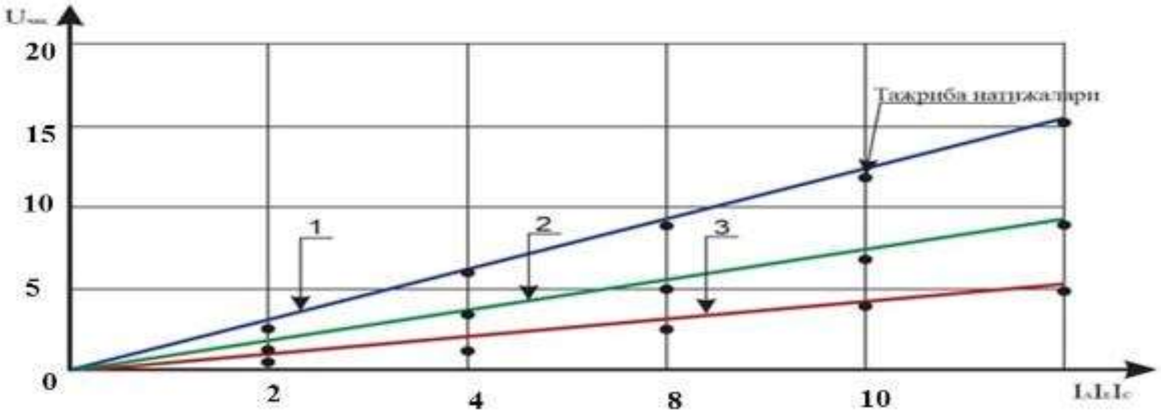

Figure 3. A graph of the dependence of the output (U_{out}) voltage on the number of primary windings.

Graph of dependence of the output voltage (U_{out}) on the number of primary windings for the case when the number of primary windings of the converter is equal to W_1= 2(3), W_1= 3(2), W_1= 5 (1) and the number of secondary windings is equal to W_2=100 Figure 3 shows. In this case, primary currents I_1=0.2-10 A, network frequency F= 50 H_z, sensitive element active surface F_{circ}= 0.002 m2, F_{steel} =0.004 m2, L_{steel} core =0.01 m steel core length, air gap Lx= 0.001 m

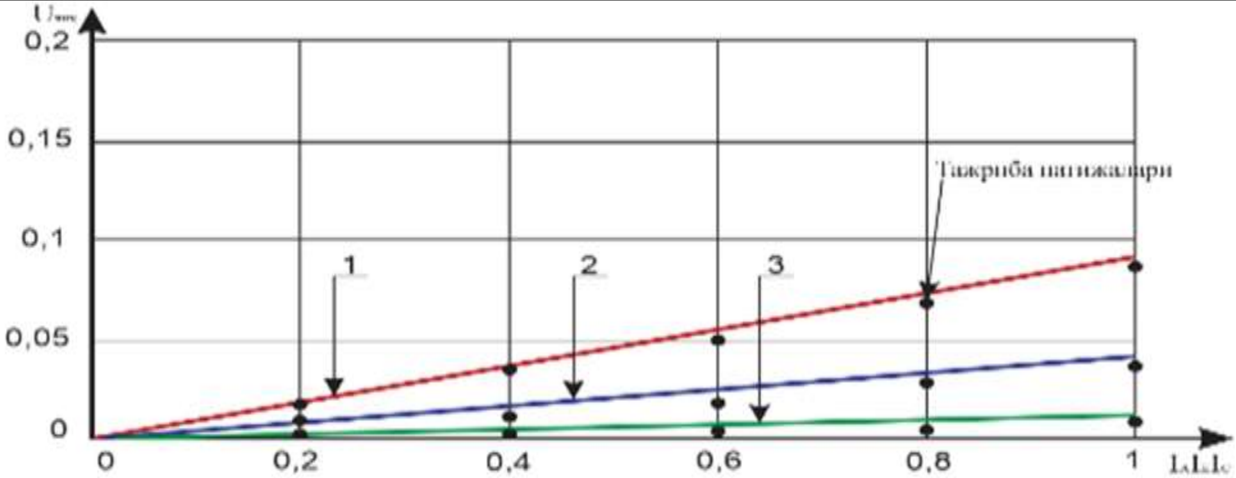

Figure 4. Graph of dependence of the output voltage (U_{out}) on different dimensions of the surface of the steel core (F_{steel}) for the case when the number of primary windings of the transformer is equal to W_1=1, and the number of secondary windings is equal to W_2=200.

In this graph (Fig. 4), primary currents I_1=0.2-1 A, mains current frequency F= 50 H_z, active surface of the sensitive element F_{circ} = 0.0001 m^2, steel core length L_{steel} core = 0.05 m, air gap L_x= 0.001 m. The steel core surface has different dimensions: F_{steel} =0.0001 m^2 (green-1), F_{steel} =0.0004 m^2 (blue-2), F_{steel} =0.0009 m^2 (red-3)

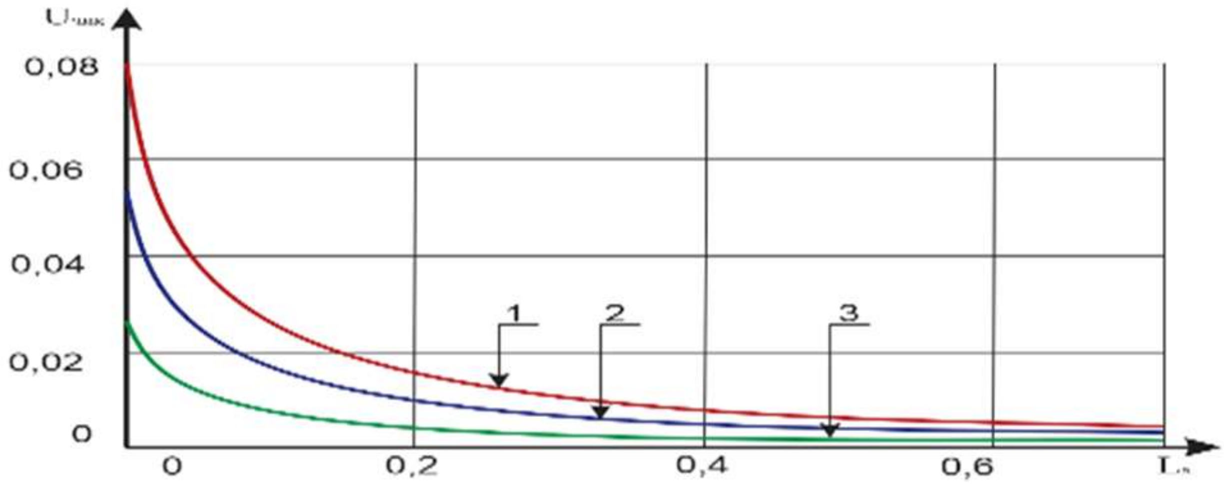

Figure 5. Graph of the dependence of the output voltage of the converter on the dimensions of the air gap (L_x).

In the graph above (Fig. 5), the number of primary coils is W_1= 2, the number of secondary coils is W_2=200, the primary currents are I_1=100 A (3), I1=200 A (2), I_1=300 A (1) described. In this case, the network frequency f= 50 H_z, the active surface of the sensitive element F_{chul}= 0.0001 m2, the active surface of the steel core F_{steel} =0.0004 m2, the length of the magnetic flux path of the steel core L_{steel} core =0.05 m. equal to the values [2].

According to the graph of output voltage dependence on the number of primary windings, the number of primary windings of the converter is equal to W_1= 2(3), W_1= 5(2), W_1= 3 (1) and the case when the number of secondary windings is equal to W_2=20 for:

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

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

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

$$U_{Э2} = 2 \cdot \pi \cdot f \cdot I_{э1} \cdot w_{ов} \cdot w_{пио} \cdot \int_0^{l_{x.o}} \Phi_{\mu g}(x) \cdot dx$$

where f is the primary current frequency; Ie1-primary input current value;

wSE- the number of windings of the sensitive element; wov- the number of wraps of the primary element; lx.o - the height of the air gap; F $_{\mu g}(x)$- magnetic flux.

Conclusions and suggestions

From the research results of distributed parameter models, it can be concluded that static and dynamic models of three-phase, three-sensing element electromagnetic current-to-voltage converters have sensitive elements of size L_x= 0.0003-0.001 m. when placed in the air gap and the surfaces of sensitive elements F_{chul}= 0.002 m2, F_{steel} = 0.004 m2, steel core length L_{steel} core = 0.01 m. and the standard value of the output voltage (20 V) is provided when the number of secondary windings is equal to W_2=100.

From the calculation results of distributed parameter models, it can be concluded that when the value of the air gap (L_x) increases, the value of the output signal in the form of voltage (U_{echiq}) decreases sharply, the increase in the number of coils of sensitive elements has a direct effect on the change in the value of the output signal and the change in the cross-section of the sensitive elements affects the output in the form of a signal provides a linear change in voltage.

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