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REVIEW OF DYNAMIC CHARACTERISTICS OF SECONDARY CURRENT SENSORS OF REACTIVE POWER SOURCES

Abstract*: In this work, the structure of the sensor for the conversion of reactive power to multiple voltages of reactive power networks, the structure of the sensor that provides a signal to the control and management devices of reactive power and the algorithm for modeling the processes occurring in it, based on the created algorithm, model, the results of the dynamic descriptions studied on the basis of the analytical expression of the graph model.*

Key words*: power supply system, reactive power and power, primary currents, sensor, control, management, voltage, signal, graph model, analytical expression, dynamic description, stagnation time.*

Language*: English*

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Introduction

Research on the dynamic characteristics of the sensor of conversion of primary currents to secondary voltage of reactive energy and power flowing from power supply systems (PSS) networks, modeling of processes occurring in the sensor, research clarity and analytical expression of highly formalized graph model and graph model [1-2].

Providing consumers with uninterrupted quality energy through PSSs requires not only the correct selection of active and reactive power sources and power grids, but also their reliable control and management systems, devices and sensors, as well as real-time continuous monitoring [2-5].

The general structure of PSS networks and the directions of $I_{A\gamma}$, $I_{B\gamma}$, $I_{C\gamma}$, $I_{A\Delta}$, $I_{B\Delta}$, $I_{C\Delta}$- primary currents of reactive power sources and the principle of installation of the sensor in PSS are shown in Figure 1. The general structure of PSS networks and reactive power sources. The directions of the primary currents

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$I_{A\gamma}$, $I_{B\gamma}$, $I_{C\gamma}$, $I_{A\Delta}$, $I_{B\Delta}$, $I_{C\Delta}$- and the principle of installation of the sensor in the PSS are shown in Figure 1.

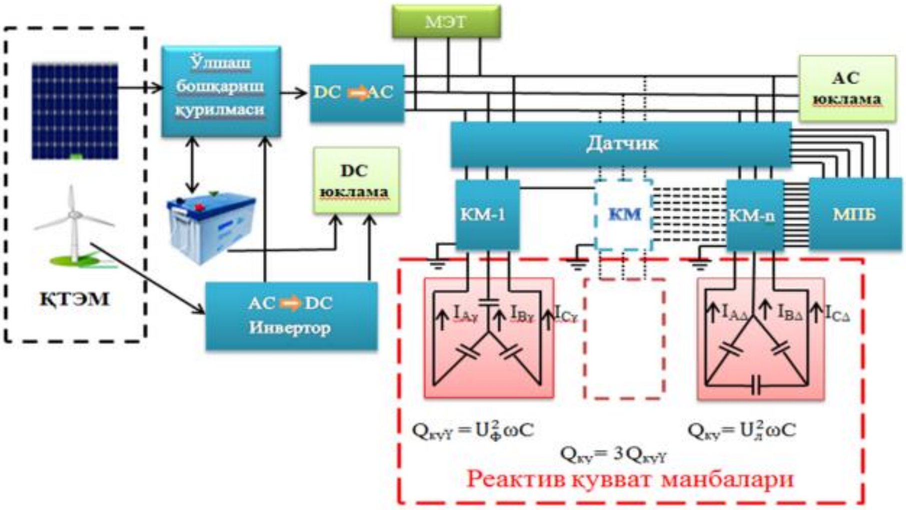


Figure 1. The general structure of PSS networks, $I_{A\gamma}$, $I_{B\gamma}$, $I_{C\gamma}$, $I_{A\Delta}$, $I_{B\Delta}$, $I_{C\Delta}$ - the direction of the primary currents of reactive power sources and the principle of installation of the sensor.

where RES is a renewable energy source, CPS is a centralized power supply system, DC → AC is a device that converts AC to AC; DC load - alternating current load; AC → DC AC converter;

CPS - centralized power supply; KM-1, KM-n- contactors; MPC-microprocessor control; AC load - alternating current load.

Alarm conversion process

Investigation of the dynamic characteristics of sensors that convert primary currents of PSS reactive power sources to secondary voltages, $I_э$- generating $U_{эч}$-output voltages of the sensor with primary currents, Φ_μ - of magnetic sensing elements, $S_{CЭ}$ - cross-sectional area, sensor sensing element, $w_{cэ}$- number of packages, the part where the sensing elements are located in the magnetic replacement part $l_{x.o}$ it is necessary to determine whether the geometric dimensions depend on the acceptable variation ranges and the variable geometric dimensions of the magnetic core [1-5].

The structure of the magnetic part of the sensor for the conversion of primary currents of PSS reactive power sources $I_{A\gamma}$, $I_{B\gamma}$, $I_{C\gamma}$, $I_{A\Delta}$, $I_{B\Delta}$, $I_{C\Delta}$ - to secondary voltage is shown in Figure 2.

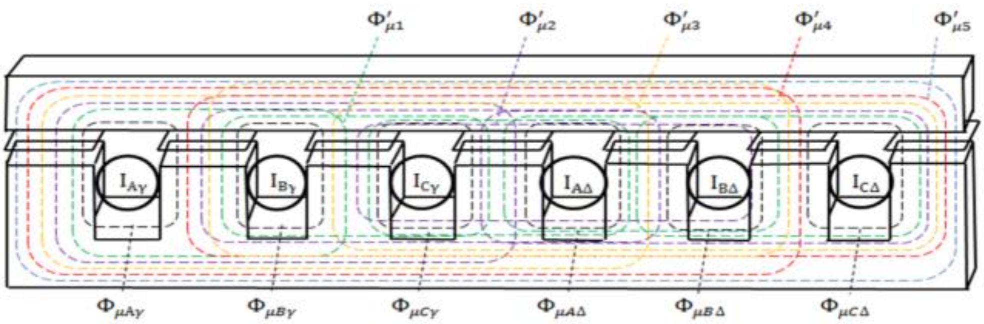


Figure 2. $I_{A\gamma}$, $I_{B\gamma}$,$I_{C\gamma}$, $I_{A\Delta}$, $I_{B\Delta}$,$I_{C\Delta}$- is the magnetic part of the sensor that converts primary currents to secondary voltage.

When the primary currents of PSS reactive power sources flow through the sensor's first $I_{A\gamma}$, second $I_{B\gamma}$ third $I_{C\gamma}$, fourth $I_{A\Delta}$, fifth $I_{B\Delta}$, or sixth $I_{C\Delta}$ excitation coils, in the common magnetic core and parallel cores $\Phi_{\mu A\gamma}$, $\Phi_{\mu B\gamma}$, $\Phi_{\mu C\gamma}$, $\Phi_{\mu A\Delta}$, $\Phi_{\mu B\Delta}$ва $\Phi_{\mu C\Delta}$ magnetic currents are generated, which also flow through the air gap between the cores.

The magnetic currents source, $\Phi_{\mu A\gamma}$, $\Phi_{\mu B\gamma}$, $\Phi_{\mu C\gamma}$, $\Phi_{\mu A\Delta}$, $\Phi_{\mu B\Delta}$ and $\Phi_{\mu C\Delta}$ of the change sensor, which provide a signal in the form of a secondary voltage for the control and management of the primary currents of PSS reactive power sources, reactive power sources star-connected single-phase $I_{A\gamma}$, two-phase $I_{A\gamma}$, $I_{B\gamma}$ or $I_{B\gamma}$, $I_{C\gamma}$ and three-phase $I_{A\gamma}$, $I_{B\gamma}$, $I_{C\gamma}$ and triangular connected single phase $I_{A\Delta}$, two-phase $I_{A\Delta}$, $I_{B\Delta}$ or $I_{B\Delta}$, $I_{C\Delta}$ and three-phase $I_{A\Delta}$, $I_{B\Delta}$, $I_{C\Delta}$ currents, at the outputs of the sensing element (simple or flat measuring tape, gerkoe, etc.) signals in the form of $U_{a\gamma}$, $U_{в\gamma}$, $U_{c\gamma}$, $U_{a\Delta}$, $U_{в\Delta}$, and $U_{c\Delta}$- output voltages in amounts corresponding to the currents of reactive power sources.

In the control and management of primary currents generated by ETT power supplies and flowing from the transmission line using modern electronic and microprocessor means at the rated current of the electrical device or at the outputs of the sensing elements at a nominal cross-section of the conductor for a long time , $U_{a\gamma}$, $U_{в\gamma}$, $U_{c\gamma}$, $U_{a\Delta}$, $U_{в\Delta}$, and $U_{c\Delta}$ are required to form. F_{μ}- magnetic driving forces (m.d.f) generated by PSS sources and generating currents $I_{A\gamma}$, $I_{B\gamma}$, $I_{C\gamma}$, $I_{A\Delta}$, $I_{B\Delta}$, $I_{C\Delta}$ flowing from power transmission lines) generating Φ_{μ}- magnetic currents cross the surfaces of sensing elements located on the corresponding base in the magnetic transformation section and on the basis of interacting magnetic currents $I_{A\gamma}$, $I_{B\gamma}$, $I_{C\gamma}$, $I_{A\Delta}$, $I_{B\Delta}$, $I_{C\Delta}$ The process of converting primary currents to $U_{a\gamma}$, $U_{в\gamma}$, $U_{c\gamma}$, $U_{a\Delta}$, $U_{в\Delta}$ *and* $U_{c\Delta}$–secondary voltages, output signals.

Research model

Figure 3 shows a graphical model that corresponds to the structure of the magnetic part of the change sensor, which provides a signal in the form of a secondary voltage for the control and management of primary currents of PSS reactive power sources and reflects the processes taking place in the magnetic switching part [6].

Figure 3. A graphical model that corresponds to the structure of the magnetic part of the sensor for the conversion of primary currents to secondary voltage and reflects the processes taking place in the magnetic switching part.

In the graph model, which corresponds to the structure of the magnetic part of the sensor and reflects the processes taking place in the magnetic change part, $K_{\Phi\mu U э}=w_{2ч}$ - Φ_{μ} is the coefficient of interconnection between magnetic currents and $U_{эч}$- output voltages. Can take values up to $w_{2ч}$=1÷20 windings [7, 9-11]

In the graph model, which corresponds to the structure of the magnetic part of the sensor and reflects the processes taking place in the magnetic change part, $K_{\Phi\mu U э}=w_{2ч}$ - Φ_{μ} is the coefficient of interconnection between magnetic currents and $U_{эч}$- output voltage, it can take values up to $w_{2ч}$=1÷20 windings based on the requirement that the output voltage be rated at the specified values of the primary currents (20V) [7, 9-11].

Analytical expressions of dynamic descriptions

$I_{A\gamma}$, $I_{B\gamma}$, $I_{C\gamma}$, $I_{A\Delta}$, $I_{B\Delta}$ ва $I_{C\Delta}$ Flowing from PSS reactive power sources and networks - $U_{a\gamma}$, $U_{в\gamma}$, $U_{c\gamma}$, $U_{a\Delta}$, $U_{в\Delta}$, ва $U_{c\Delta}$- for control and management of primary currents. the dynamic characteristics of the sensor providing a signal in the form of a secondary voltage are studied using the following analytical expression formed on the basis of the graph model shown in Figure 3 [6,7-12]:

$$U_{A\gamma} = K_{\Phi\mu U э}\Pi_{\mu 1}W(F_{\mu 11}, F_{\mu 14})K_{IэF\,\mu}I_{A\gamma}\sin\omega t + I_{AM}e^{-\frac{t}{T}}$$

$$U_{B\gamma} = K_{\Phi\mu U э}\Pi_{\mu 2}W(F_{\mu 21}, F_{\mu 24})K_{IэF\,\mu}I_{B\gamma}(\sin\omega t + 120^{0}) + I_{BM}e^{-\frac{t}{T}}$$

$$U_{C\gamma} = K_{\Phi\mu U_Э}\Pi_{\mu 3}W(F_{\mu 31}, F_{\mu 34})K_{IЭF\,\mu}I_{C\gamma}(\sin\omega t - 120^0) + I_{CM}e^{-\frac{t}{T}}$$
$$U_{A\Delta} = K_{\Phi\mu U_Э}\Pi_{\mu 4}W(F_{\mu 41}, F_{\mu 44})K_{IЭF\,\mu}I_{A\Delta}\sin(\omega t) + I_{AM}e^{-\frac{t}{T}}$$
$$U_{B\Delta} = K_{\Phi\mu U_Э}\Pi_{\mu 5}W(F_{\mu 51}, F_{\mu 54})K_{IЭF\,\mu}I_{B\Delta}(\sin\omega t + 120^0) + I_{BM}e^{-\frac{t}{T}}$$
$$U_{C\Delta} = K_{\Phi\mu U_Э}\Pi_{\mu 6}W(F_{\mu 61}, F_{\mu 64})K_{IЭF\,\mu}I_{C\Delta}(\sin\omega t - 120^0) + I_{CM}e^{-\frac{t}{T}}$$

where: $\Pi_{\mu j} = \frac{\mu_0 F_j}{\delta_{\mu j}}$ $(j=\overline{1,6})$ – magnetic parameter of the change part of the sensor generated $U_{Эч}$ No output voltages ($\mu_0 -$ magnetic absorption of air gaps with sensing element $\mu_0 = 1{,}25 * 10^{-6}$Гн/м);

s - is the cross-sectional area of the magnetic core piece on which the sensing elements are mounted, for example axb=0.01x0.01 м^2;

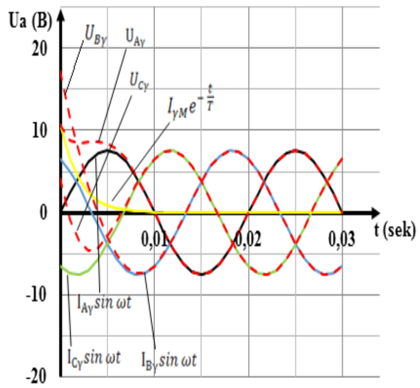
$\delta_\mu -$ heights of air gaps with sensing elements (m);

$W(F_{\mu ij}, F_{\mu in}) -$ is the transfer function of the magnetic switching part.

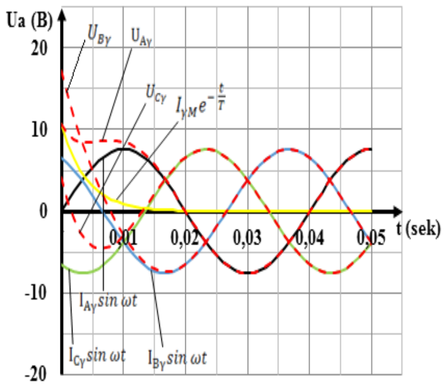
$K_{IЭF\,\mu} - \omega_{jk} - I_Э -$Primary currents flowing from PSS networks and $F_\mu -$ m.d.f formed in a magnetic converter. The inter-chain coefficient between is usually $\omega_{jk} = 1$.

$I_{A\gamma}$, $I_{B\gamma}$, $I_{C\gamma}$, $I_{A\Delta}$, $I_{B\Delta}$, $I_{C\Delta} -$ PSS Primary currents supplied by power sources connected to γ - star and Δ - triangle circuits (A).

The primary input currents of the dynamic changes occurring in the sensor, depending on the magnitudes and parameters of the magnetic currents and output voltages they generate, are given in the graphs of change (Fig. 4) and (Fig. 5).

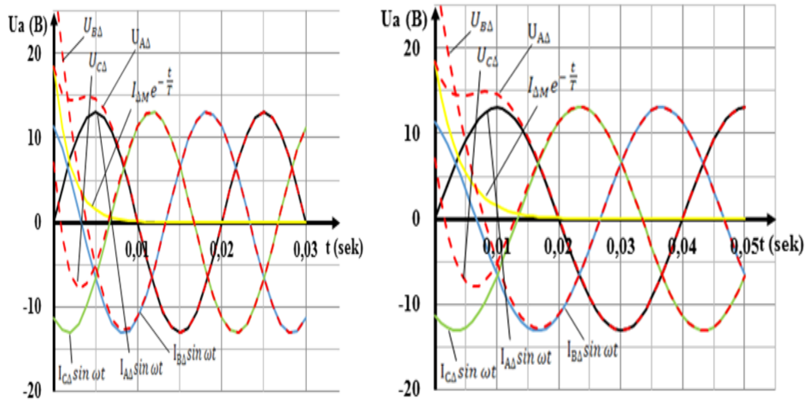


a)



b)

Figure 4. Dynamic characteristics of the relationship between the primary currents of the sensor and the output voltage (PSS reactive power sources are star-connected: a) when T = 0.02 b) when T = 0.04).



a) b)

Figure 5. Dynamic characteristics of the relationship between the primary currents and secondary voltages of the sensor (PSS reactive power sources are connected in a triangle: a) when T = 0.02 b) when T = 0.04).

Results

1. The magnetic currents generated by the PSS power supplies and generated by the currents $I_{A\gamma}$,$I_{B\gamma}$,$I_{C\gamma}$,$I_{A\Delta}$,$I_{B\Delta}$ and $I_{C\Delta}$ flowing through the electric networks in the magnetic cores F_{μ}- m.d.f., A graph model has been developed for the study of the processes of conversion of primary currents to $U_{эч}$– secondary output voltages on the basis of Φ_{μ} - magnetic fluxes.

2. Based on the dynamic changes that occur in the sensor of currents flowing through the mains, developed by reactive power sources, it can be concluded that when the inertia period of the transmission line is T=0,02, the currents flowing from the primary winding of the sensor are 0,008 - 0,012 sec from the connection to the PSS networks, after passing, while the inertia period is T = 0.04, the currents are 0.015 to 0.025 sec when connected to the mains, after reaching its constant value.

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