Modeling and research multiphases signal transducers of power control systems

I.Kh.Siddikov
TUIT named after Muhammad
al-Khwarizmi
Tashkent, Uzbekistan
ikhsiddikov@mail.ru

A.A.Abdumalikov
TUIT named after Muhammad
al-Khwarizmi
Tashkent, Uzbekistan
akmalabdumalikov6@gmail.com

M.T.Makhsudov
Andijan Mashinobuilding Institute
Andijan, Uzbekistan
mohirbek2702@mail.ru

Abstract—Presented model and results of research of transforming processes, which flowing in converting elements and circuits of transducer of primary multiphases electrical current to secondary signal. Modeling and research of main characteristics of primary measure transducers of multiphase primary electrical currents of power energy to secondary signal based to graph model with high formalized, effectively and digital-based cloud computing technology.

Keywords— transforming processes, multiphases transducer, primary electrical current, secondary signal, current, graph model, characteristics.

I. INTRODUCTION

The main characteristics of transducers, which of transforming primary currents for power systems (PS), to secondary signal – signals, which need for control of PS classically recommending on the basis of modern analytical models and computing technologies [1-3].

The structure of a typical model of measuring systems with primary transducers of multiphases currents of power energy is given in fig. 1.
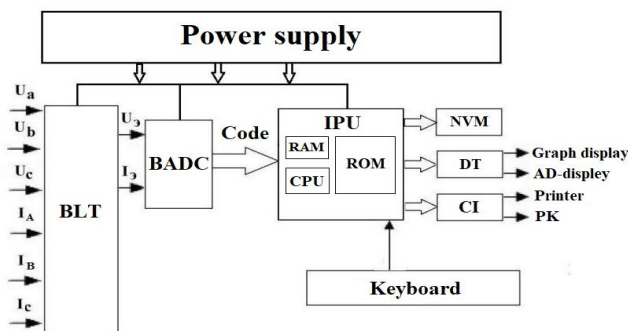

Fig. 1. Model of structure of multiphases signal nets of power control systems .

The structure of control units:
BLT - a block of large-scale transformations;
BADC - block of analog-to-digital converter;
IPU - information processing unit;
RAM - random access memory;
CPU - central processing unit;
ROM - read-only memory;
NVM - non-volatile memory;
DT - display tool;
CI - communication interface;
AD - alphanumeric display.

The measured voltages and currents are supplied to input terminals of the block of scale transducers, in which, by analog processing, signals proportional to parameters of output voltage are formed, i.e., scale transformations occur to level (approximately 5 V) necessary [4-10].

Control and monitoring of multiphase's electrical currents of PS on the base of multiphase currents transducers provides transformation of electricity measuring values-signal and have possible to use different physical and technical effects [3-5].

Research of main characteristics of multiphase's currents transducers required to determine relations between Ie – input multiphase currents of PS and output signal - electrical voltages Ueout on the basis of Sse – sensitive elements parameters, magnetic flux - Qμ and number of secondary windings wse which depend from geometric parameters of magnetics materials, sensitive elements of transducers and values of their ranges [6-8].

The multiphases primary currents of PS, flowing through primary windings of transducers, generate magnetic fluxes in magnetic cores, which flows through sensitive elements - secondary windings. The transducers of controlling and adjusting multiphase primary currents of PS transform a secondary signal depend from magnetic fluxes and submit output values - electrical signals [7-12].

The sensitive elements of multiphase's transducers of PS are designed and insulated as sheets and produce normalized ignal with quantities up to 20 V [13-14].

II. METHODOLOGY

The analytical method of research of multiphase's current transducers based on graph model describe operational quantities and parameters of transducers, complex of physical and technical processes occurring, as well as adjusting conditions of PS [11-18].

Graph model of the signal transforming process in multiphases transducers of primary current of power nets given in fig. 2.
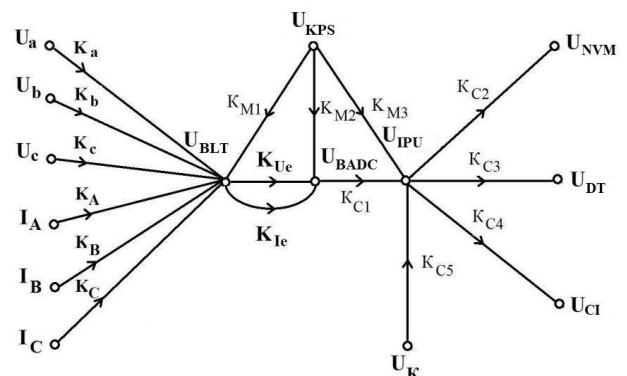

Fig. 2. Graph model of the signal transforming process.

The analytical equations of the output voltages on the transducers structure based on location of multiphase primary current fluxes, shape of magnetic flux's and a type of transducers, a number of rolls and transforming parameters and formed as follows [14-18]:

$$U_{eouta}(t) = -R_{ese1}I_{eouta}(t)$$
$$-\frac{L_{ese1}dI_{eouta}(t)}{dt} + \frac{w_{se2}dQ_B(t)}{dt} + \frac{w_{se3}dQ_C(t)}{dt}, \quad (1)$$

$$U_{eoutb}(t) = -R_{ese1}I_{eoutb}(t)$$
$$-\frac{L_{ese2}dI_{eoutb}(t)}{dt} + \frac{w_{se1}dQ_A(t)}{dt} + \frac{w_{se3}dQ_C(t)}{dt}, \quad (2)$$

$$U_{eoutc}(t) = -R_{ese1}I_{eoutc}(t)$$
$$-\frac{L_{ese3}dI_{eouts}(t)}{dt} + \frac{w_{se1}dQ_A(t)}{dt} + \frac{w_{se2}dQ_B(t)}{dt}, \quad (3)$$

here: R_{ese1}, R_{ese2}, R_{ese3}, L_{ese1}, L_{ese2}, L_{ese3} – active resistance and inductance of transducers;

w_{se1}, w_{se2}, w_{se3} - number of windings of sensitively elements;

When electrical inductance of PS are $L_{EI} = L_{EII} = L_{EIII} = 0$, nets will an increase in initial value of multiphase currents, then magnetic fluxes will attain a steady-state sinusoidal value [4,8].

A reliable assessment of electric power quality indicators (PQI) in the nets and the development of effective measures aimed at ensuring electric power quality are impossible without instrumental control. To carry out such control, specialized measuring instruments (SMI) are required. Intensive development of microprocessor technology has allowed domestic developers to create multifunctional SMI, designed to control and analyze the quality of electricity [13].

The only condition when choosing a SMI is that all means must comply with the requirements of GOST 13109-97 [3]. In part regarding the measurement and control algorithms of the PQI and the permissible measurement errors. The list of measured PQI is established by GOST 13109-97, but can be expanded depending on the tasks to be solved.

III. RESULTS

The static characteristics between current and the sensor output signal, shown in figures 3.a and 3.b.
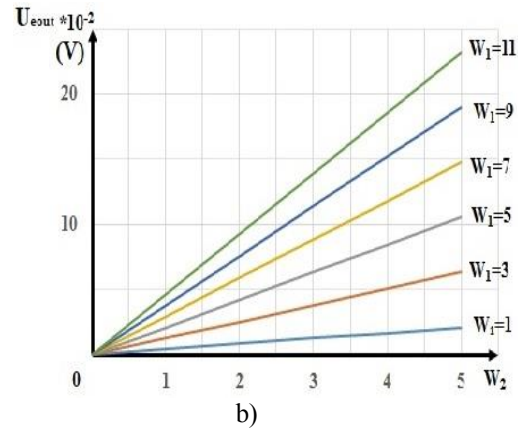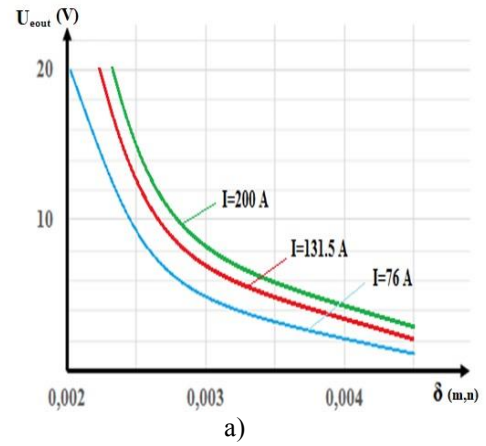

a)

b)

Fig.3. Influence of sensor parameters on output voltage. a) effect of airspace; b) effect of the number of primary windings.

The dynamic characteristics between current and the sensor output signal of multiphases current transducers of power nets, shown in fig.3.
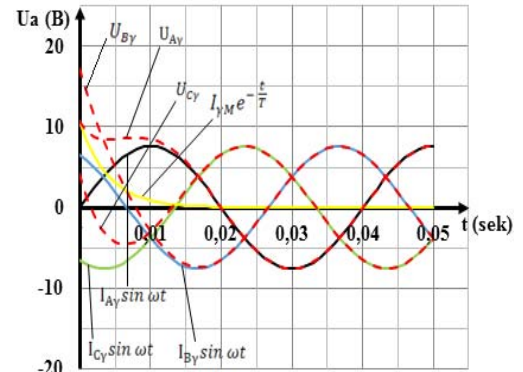

Fig. 4. The dynamic characteristics of transducers of multiphase currents.

IV. ERROR ANALYSIS

The Metrological characteristics of sensors of multiphase primary currents of PS to secondary signal based on static characteristics and illustrated in fig.4, as shown in characteristic, accuracy, linearity of output characteristics, identical sensitivity among in range of change [14-18]:

$$I_{A\gamma} = 38A; \; U'_{a\gamma} = 10V; \; U''_{a\gamma} = 10{,}18V; \quad (4)$$

$$\Delta = \frac{(U''_{a\gamma} - U'_{a\gamma})}{U'_{a\gamma}} * 100\% = \frac{(10,18 - 10)}{10} * 100\% = 1,8\%;$$

$$(5)$$

$$\Delta = \frac{(U''_{a\gamma} - U'_{a\gamma})}{U'_{a\gamma}} * 100\% = \frac{(20,37 - 20)}{20} * 100\% = 1,81\%;$$
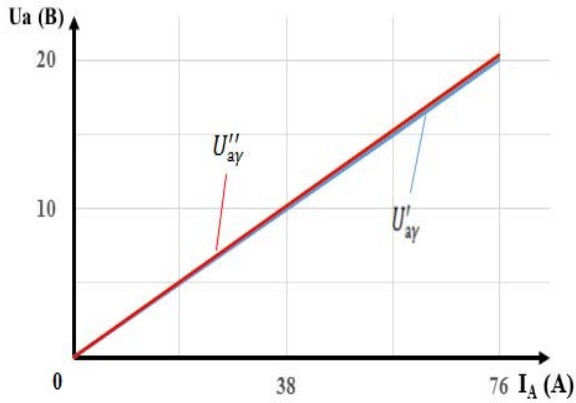
$$(6)$$

Fig. 5. The static characteristics of multiphases signal transducers.

here:

U' - output voltage from collected parameters graph model;

U'' - output voltage from distributed parameters graph model.

In the multiphase primary currents transducers have a sources of errors are various factors - temperature, humidity, external magnetic fields, ω_e – frequency, $W[I_{ein}, F_\mu]$-correlation coefficients of different nature change values, physical parameters of excitation materials conductors of current, affected and other factors effects, which influence to as multiphase primary currents - I_{ein} and also to secondary voltage - U_{eout} [16].

Research of accumulated errors of transducers of multiphase primary currents of PS consist: input magnetic transform part, i.e. primary currents transform to m.m.f. F_μ, i.e. $I_e \rightarrow F_\mu$, in this case transformation errors is $\delta_1 = 0,15$ (± 0.15% deviation from the nominal value of electrical and magnetic values due to elements of transforming - conductors and magnetic core [14]).

Due to distribute parameters of transforming of m.m.f. F_μ of magnetic fluxes Q_μ, errors consist $\delta_2 = 0,15$, and determine on the base deviation of magnitudes and thresholds ± 0.15% from nominal value, based on the scattering of the parameters and due to transform errors of Q_μ - magnetic fluxes to U_{eout} - output signal, i.e. $Q_\mu \rightarrow U_{eout}$ [22] :

$$\delta_\Sigma = \sqrt{\delta_1^2 + \delta_2^2 + \delta_3^2} = \sqrt{0,15^2 + 0,15^2 + 0,1^2} = 0,18 \quad (7)$$

The value of entropy of error for investigated transducer determined as [15]:

$$\Delta = K_e \delta_\Sigma \cdot = 2,07 \text{ x } 0,18 = 0,38$$

As taken from result of calculations and experiments, the multiphases currents transducers of PS to electrical signal is $\Delta = 0.38$, i.e ± 0.38%.

The accuracy for this type of multiphase primary current transducers determined as 0.5, which is ± 0.5% on nominale currents of PS.

V. CONCLUSION

1. The graph model of transforming processes of transducers of multiphase current of power transmission nets is adequate to the experimental design of transducers and shown a construction and processes of transforming electrical and magnetic quantities and parameters and can be increased by 1.8% on the basis of graph model with distributed parameters.

2. The graph model of multiphases transducers and analytical equations for research of main characteristics of primary transducers based on highly formalized and transparent physical and technical effects, with structure involved in transforming process, have high possibilities during research main characteristics of transducers with collected and distributed parameters.

3. On the basis of static and dynamic diagrams of multiphase currents transducers, which depend of magnitude and parameters of magnetic fluxes and output signal, may be concluded, that a multiphase's currents, which flowing in transforming circuits of transforming elements, flowing from nets PS output signal stabilizes at inertial of loads is T = 0.02 during 0.008 - 0.012 sec. after connection of primary currents to power transforming net of PS.

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