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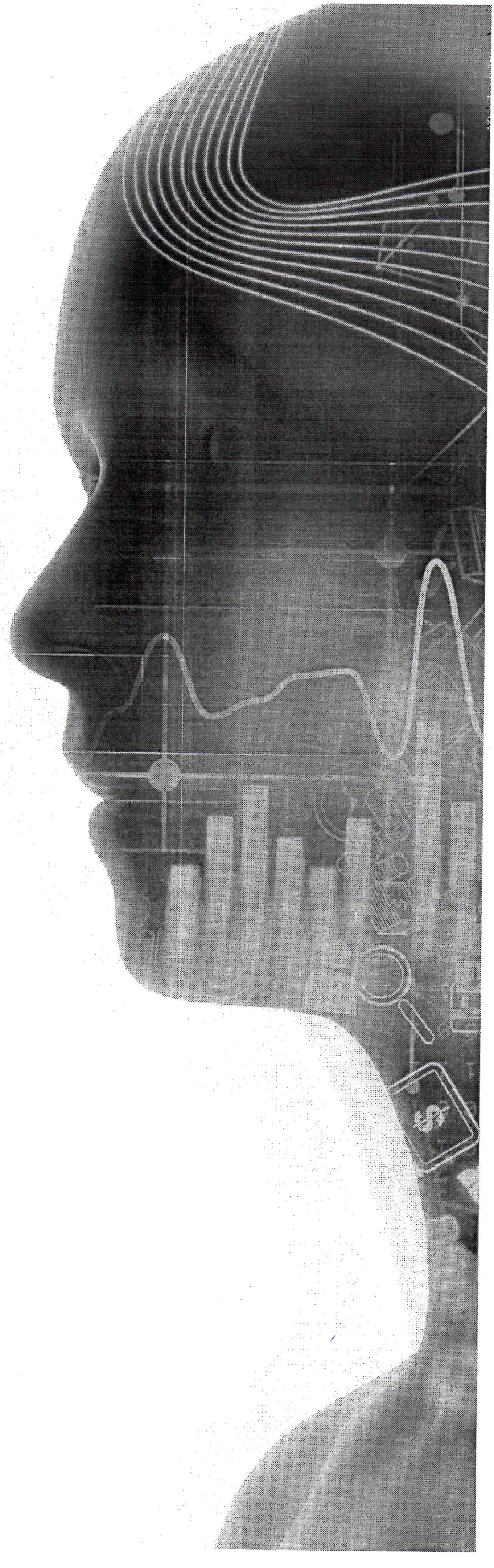

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RESEARCH OF TRANSFORMING CIRCUITS OF ELECTROMAGNETS SENSOR WITH DISTRIBUTED PARAMETERS

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ABSTRACT. Modeling of transforming circuits of sensors with distributed parameters gave possibility research input values as electrical current, voltage and ets. and output signals as electrical voltage of the basis of using sensitive elements. In article collect results modeling and research transforming circuit of primary sensors with distributed magnetic parameters.

INTRODUCTION

The primary electromagnet sensors with distributed parameters (magnetic core, air gaps, electrically conductive materials, dielectrics - as an insulating plate, etc.) of control systems have a very different geometrical configuration and structure. As well as distributed character (nonsymmetrical and nonlinear values) of transforming primary circuit to secondary voltage and three-dimensionality structure construction of sensor elements of on volume of signal from sensor and control systems (current and voltage) of electrical circuit, is clear that modeling and calculating them in full a difficult task. In this article carried out modeling and research of transformation circuit, splitting them into separate components and simple elementary parts based on replacing it with a three-dimensional electric circuit of substitution - a graph model of transforming circuits of primary sensors [1,2].

MAIN PART

The research oriented on stage of analysis and modeling of elements' constructions on basis of graph model - representation of principles of transformation of distributed parameters of electrical physical value as primary sensors of control systems. The solution of problem of modeling principles of operation of sensors of current in graph models is reduced to the procedure for transforming the initial graph consisting node, value - incoming $I_{э1}$ - primary current to $U_{э2}$ -secondary voltage - the output electrical signal.

The graph model characterizes value of participates in the process of transformation of electromagnetic current and voltage sensors, and reflect the nature of the functional relationship between the values and parameters of the transformation circuit and elements. Design of the circuits for electromagnetic current and voltage sensors, the number of which continuously increases as new physic technical effects are used in them, raises the problem of their systematization and selection of optimal quantities and parameters of the transformation and circuit that meets the requirements of a modern control system [3,4].

The methods for modeling and calculating of circuits of transformation sensors and measurement systems of current and voltages of labors sensors, are very approximate and do not always allow for the peculiarities of transforming of signal from sensors [4-7].

Based on the magnetic circuits of the transformation sensors and measurement systems of current and voltages with distributed parameters, the algorithm for constructing the model of transformation elements - the magnetic system or circuit - is explained, since the structure, shape and geometric dimensions, as well as magnetic materials of the magnetic circuit, reflect the essence of the magnetic circuits of the transformation electromagnetic current and voltage sensors.

On the basis of this research, the real physical transformation circuit of current and voltage sensors, is replaced by an equivalent model with longitudinally, transversely and vertically distributed parameters or a model, represented in three-dimensional coordinate system (i, j, k).

The parameters and values of model are determined on the basis of geometric dimensions and taking into account unit-specific distributed parameters of sensors.

Then resistances of elementary sections of equivalent model of transformation circuit are determined from equations [5-11]:

$$R_{\mu\, i,j,k} = R_{\mu\, i,j,k}\, \Delta X_i \,, \tag{1}$$

$$\Pi 0_{\mu i,j,k} = \Pi_{\mu i,j,k} \Delta X0_j \,, \tag{2}$$

$$\Pi 1_{\mu i,j,k} = \Pi_{\mu i,j,k} \Delta X1_k \,, \tag{3}$$

where: $\Delta X_i = X / N, \Delta X0_j = X0 / M, \quad \Delta X1_k = X1 / K$ - elementary parts circuit;

$X,\ X0,\ X1$ - length of transformation sites;

X - longitudinal length of sections;

$X0$ - vertical length of sections;

$X1$ - transverse length;

N, M, L – number of dividing sections.

The algorithm of modeling of circuit of primary electromagnet sensors of current is represented in following steps:

1. Complex circuit of the transformation of sensors will be divided to elementary parts (taking into account magnetic circuit, air gaps, additional cores, and scattering fluxes) according to principle of magnetic flux constant at each section of conversion chain.

2. The preliminary distribution of the magnet moving force (m.m.f.) and magnetic flux along sections of circuit defined.

A preliminary distribution of magnetic induction in sections *i* and *j*, where there is an air gap is defined as follows:

$$B_{i,j} = \frac{\Phi_{i,j} \Pi 0_{\mu i,j}}{\delta_{i,j}}, \tag{4}$$

where $\Phi_{i,j}$ - magnetic fluxes in sections of circuit; $\Pi_{\mu i,j}$ and $\Pi 0_{\mu i,j}$ are magnetic conductivities of *i* and *j*-th sections of circuit.

When primary current flow through current circuit - primary winding of electromagnetic sensor $I_{\text{эвх}}$ is set, then m.m.f. in magnetic circuit is defined as follows:

$$F_{i,j} = I_{\text{эвх}} w_{\text{ов}} \,, \tag{5}$$

where: $w_{\text{ов}}$ - number of turns of current conductor - field winding.

The magnetic flux is determined as follows:

$$\Phi_{i,j} = \Pi 0_{\mu i,j}(F_{i,j} - F_{i,j+1}). \quad (6)$$

3. The complex conductivity of each longitudinal *i, j*-th section will defined as:

$$\Pi 0_{\mu i,j} = Y_{\mu i,j} = Z^{-1}_{\mu i,j} = g_{\mu i,j} - jb_{\mu i,j}, \quad (7)$$

where $Z_{\mu i,j} = R_{\mu i,j} + jX_{\mu i,j}$ is complex magnetic resistance of *i, j*-th section.

4. For the considered magnetic section of transmission circuit: $R_{\mu i,j} = \rho l_{\mu i,j} / F_{i,j}$ - active magnetic resistance – parameter of *i, j*-th section, characterizing property of magnetization of magnetic material under influence of applied force; $X_{\mu i,j} = \rho l_{\mu i,j} / S_{i,j}$ - reactive magnetic resistance of *i, j*-th section, characterizing loss of magnetizing force on eddy currents and hysteresis; $\rho R_{\mu i,j}$ and $\rho X_{\mu i,j}$ respectively, specific reactive and reactive magnetic resistances of *i, j*-th section of magnetic circuit, determined depending on magnetic induction and magnetic characteristics; length of *i, j*-th section of magnetic circuit of transformation.

When *i, j*-th segment of circuit is an air gap, then its active magnetic conductivity determine as

$$\Pi 0_{\mu i,j} = R^{-1}_{\mu i,j} = \sqrt{2}\mu_0 \frac{F_{i,j,k}}{\delta_{i,j}}, \quad (8)$$

where; *i, j* - parts of magnetic circuit; is magnetic constant of air. If *i, j*-th segment is a scattering section, then determine magnetic conductivity:

$$\Pi 0_{\mathrm{p}i,j} = g_{\mu} l_{\mu \mathrm{p} i,j}, \quad (9)$$

where specific magnetic conductivity of the scattering, obtained from structure and analytically from known relationships.

5. The field of graph model of designated nodal points will taking put into account their mutual arrangement.

6. Connection each pair of node points graph model constructions between each other by two oppositely directed arcs according to designated nodes of initial design of transformation circuits of electromagnetic current sensors.

7. For each arc of obtained nodal subgraphs, will assigned a complex transfer equal to ratio of complex conductivity of elementary region between nodes of initial system under consideration to complex conductivity of node to which arc of graph model is directed as:

$$T_{i,j,k} = \frac{\Pi 0_{\sum i,j}}{\Pi_{\sum i,j} + \Pi 0_{\sum i,j}}. \quad (10)$$

8. The field of graph model points corresponding to given quantities (primary electric current) and these points will be considered as nodes of graph model of transformation circuit sensors We put on.

9. Connection nodes $F_{i,j}$ with arcs corresponding to complex materials of nodes of section on which source will be located in form of model.

In case, when nodes of connecting influencing quantities - fluxes. through coefficients of relationships between values of electric and magnetic value, for this cases communication means as a parameter between magnetic flux and m.m.f. of circuit of sensors determined as follows:

- for model node $F_{\mu 11}$ is determined on basis of the interchain coupling coefficient between electric and magnetic circuits. The input value at point $F_{\mu 11}$ will determined fron next equal:

The input value at the point $F_{\mu 11} = K_{IF} I_Э$;

$$\frac{F_{\mu 11} - F_{\mu 12}}{R_{\mu 11} + R1_{\mu 11}} = 0 \tag{11}$$

$$F_{\mu 11} = F_{\mu 12} \tag{12}$$

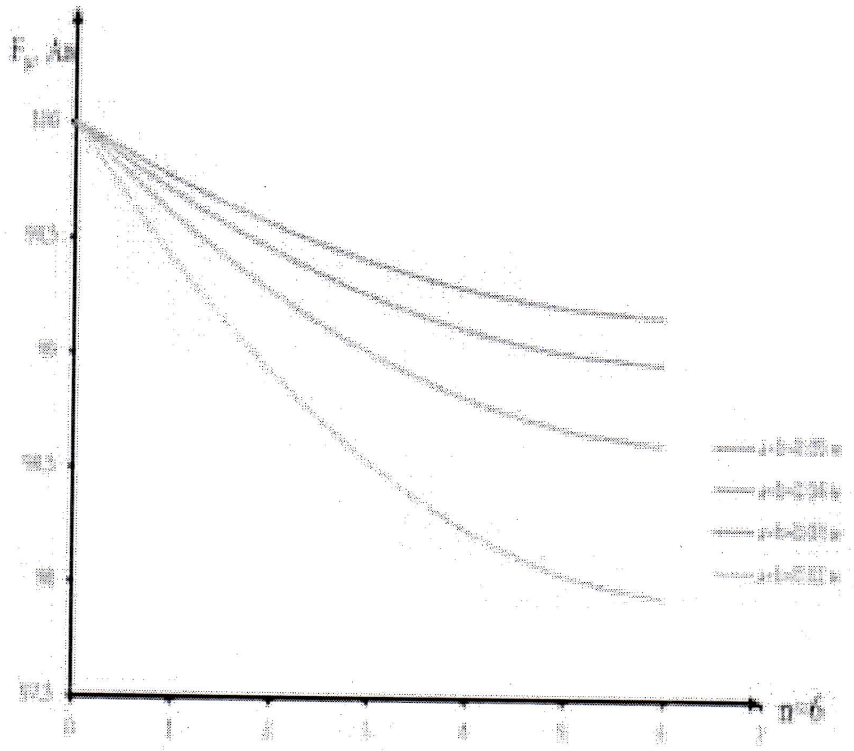
$$\frac{F_{\mu 11} - F_{\mu 12}}{R_{\mu 11}} - F_{\mu 12} \cdot G_1 = 0 \tag{13}$$

$$F_{\mu 11} - F_{\mu 12} - F_{\mu 12} \cdot G_1 \cdot R_{\mu 11} = 0 \tag{14}$$

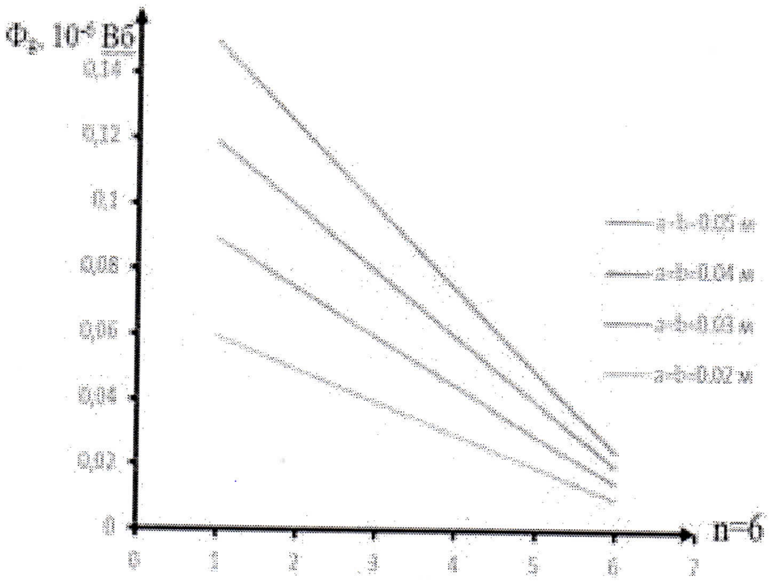
$$F_{\mu 12} = \frac{F_{\mu 12}}{1 + G_1 \cdot R_{\mu 11}} \tag{15}$$

where $R_{\mu 11} = \dfrac{l}{\mu \cdot \mu_0 \cdot a \cdot b}$; $G_1 = \dfrac{\mu_0 \cdot a \cdot b}{l_{в.з}}$ are the resistance and conductivity of the sections of the transformation circuits.

In fig.1 given the graphs of change flux and m.m.f. on longitudinal sections of transformation signal of circuit of sensors.



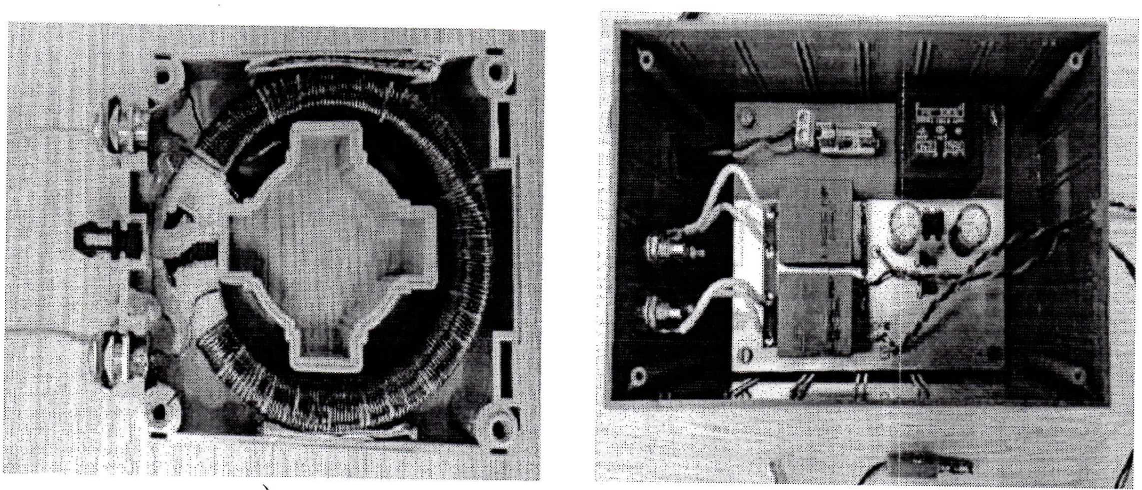
a)



b)

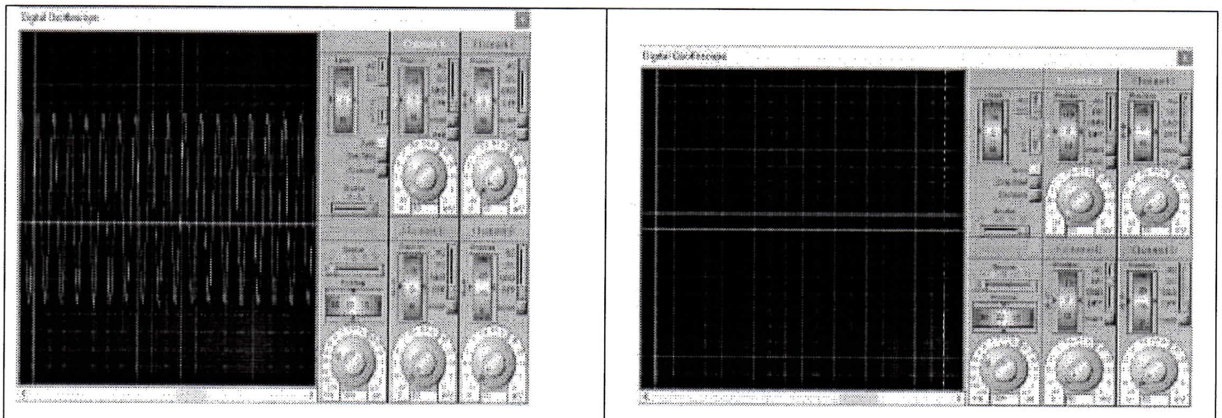
Fig.1 The graphs of change flux and m.m.f. on longitudinal sections of transformation signal of circuit of t sensors where: a – graph of changing of m.m.f.and b –graph of changing of flux

In fig. 2 and 3 presents the electromagnet sensors with distributed parameters, that transforming in real time of the values of the electrical network and the results of their practical researhs [10-12].



a) b)

Fig. 2. Electromagnets sensors with distributed parameters:
a)- the sensor on AC, b) the sensor on DC



a)	b)

Fig.3 Results of research
a)- from sensor of AC, b) – from sensor of DC

CONCLUSION

1. Motivated, that using flat measuring windings in sensors of primary current to secondary voltage as sensing element, provides unified out signal with parameters: voltage - *20* V, current - *100 mA*.

2. Installed, that value out voltages U_{eout} depends on degree of perpendicular and uniformities of crossing magnetic flow area flat measuring windings, optimal resistances and conductivities complex portioned area and structures of magnetic circuit of sensors.

3. The entropy inaccuracy of sensors of the primary current to secondary voltage does not exceed *0,2%%*.

4. Practically on the basis of results of research determined, that total reliability combined control system source of electrical power of power systems on the base of intelligent sensors and measurement systems of current to voltage with flat measuring windings forms, best value equal to *0,96*.

REFERENCE

[1] Siddikov I.Kh., Abdulaev A.Kh., Bobojanov M.K. Perfection and development of sensor controls and measuring transducers on a basis of information-energetics model//WCIS - 2002. Collection of the works. II – World conf. 4-5 June 2002 y. b-Quadrat Verlag, Azerbaijan State Oil Academy, Azerbaijan, Baku, 2002. - p.p. 310 -315.

[2] Siddikov I.Kh., Nazarov F.D., Gafurov J.F., Gaziev B.A., Khakimov M.Kh. Energy management and energy audit in energy sector of Republic Uzbekistan //Control of power system – 04: Thesis's VI – int. conf. June 16-18 2004. - Slovak Rep., High Taras, Strbske Pleso, 2004. – p.p. 230-235.

[3] Siddikov I.Kh., Khakimov M.Kh., Anarbaev M., Bedritskiy I.M., Research of the electromagnetic transdusers of the primary current to secondary voltage // Science and Education. Materials of the II International Research and practice conference. Vol. I, Publishing office of «Vela Verlag Waldkraiburg», Munich, Germany, December, 18-19, 2012. – p.p. 222-225.

[4] Siddikov I.Kh., Sattarov Kh.A., Khujamatov Kh.E. Modeling of the Transformation Elements of Power Sources Control // International Conf. on ISISCT – 2017, Tashkent, Uzbekistan, 2-4 November, 2017. https://www.scopus.com/authid/detail.uri?authorId=56230037700

[5] Siddikov I.Kh., Abubakirov A.B.,Esenbekov A.J. Najmatdinov K.M. The modern principle of design of electromagnetic transducers of the primary current to secondary voltage// International Scientific Journal "INTERNAUKA" N7 (29) 2017 Kiev.2017 p.66-68.

[6] Siddikov I.Kh., Sattarov Kh.A., Khujamatov Kh.E.,Sharjanova K. Modeling of the elements and devices of energy control systems // XXXII Межд. научно-практ. интернет-конф. «Тенденции и

перспективы развития науки и образования в условиях глобализации» 31 января 2018 г. Сб. научн. тр. Переяслав-Хмельницкий, Украина – 2018, 466-468 с.
[7] Siddikov I.Kh., Abubakirov A.B., Sarsenbaev D. The sources of errors of electromagnetics transducers // The USA Journal of Applied Sciences,CIBUNET Publ.,США N1, 2018.c34-36. RG Journal Impact: 0.79 / http://ortpublishing.ru/arhiv_publikacij_the_usa_journal_of_applied_sciences
[8] Siddikov I.Kh., Abubakirov A.B., Najmatdinov K., Sarsenbaev D.B., Kh.Sattarov, Kh.Khujamatov, I.Xonturaev, M.Maksudov. Modeling of transforming circuits of electromagnetic transducers // Wschodnioeuropejskie Czasopismo Naukowe (East European Scientific Journal). Warshav, Polska. 2018. P. 25-28.
[9] Siddikov I.Kh., Sattarov Kh.A.,Siddikov O.I.,Khujamatov Kh.E.,Khasanov D.,Olimova Sh.,Kholiqberdiev M.,Orifjonov O. Advantages Energy Conversion Systems // "Modernization of the Curricula in sphere of smart building engineering – Green Building (GREB) 574049-EPP-1-2016-1-IT-EPPKA2-CB" Program ERASMUS+ EC web-site:
https://sites.google.com/view/erasmus-greb/project-materials
[10] Siddikov I.Kh., Sattarov Kh.A.,Siddikov O.I.,Khujamatov Kh.E.,Khasanov D.,Olimova Sh.,Kholiqberdiev M.,Orifjonov O. Metrology, Standardization and Certification // "Modernization of the Curricula in sphere of smart building engineering – Green Building (GREB) 574049-EPP-1-2016-1-IT-EPPKA2-CB" Program ERASMUS+ EC web-site:
https://sites.google.com/view/erasmus-greb/project-materials
[11] Siddikov I.Kh., Sattarov Kh.A.,Khujamatov Kh.E.,Dexkhonov O.R.,Agzamova M.R. Modelling of Magnet Circuits of Electromagnetic Transducers of the Three-Phases Current// Collection of the materials. 14th International Scientific Technical Conference On Actual Problems Of Electronic Instrument Engineering (APEIE-2018)"- 44894 Proceedings, V.1, P.5, 2-6 October, 2018. –p.p. 419-422: https://www.scopus.com/authid/detail.uri?authorId=56230037700
[12] Petrova I.YU., Zaripova V.M, Lejnina Y.V.,Siddikov I.Kh. Automated system for synthesis of sensors for smart cities // Collection of the materials. XXII International Scientific Conference on Advanced In Civil Engineering "Construction the formation of living environment' Tashkent, Uzbekistan, 18-21 April, 2019 E3S Web of Conferences eISSN: 2267-1242
http://form2019.org/files/FORM2019_Program.pdf