The three-phases electromagnetic current transducers for control of reactive power of electricity consumption

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Abstract. As known, in the world more than 60-70% of generated electricity is consumed by three-phases induction electric devices - asynchronous motors. In induction electric devices as asynchronous machines, converters, transformers and ets, reactive power consume for creation of magneto moving force (m.m.f.) and magnetic flux. The control of reactive power of electricity depend from values and parameters of current transducers, which use in processes of control power consumptions. Modern control systems of values and parameters of electricity request developing and implementation of new types digital technologies and devices. In article given results of research of new three-phases current transducers, which use in processes of control of reactive power supply of induction devices and have possibilities transform asymmetrical and non-sinusoidal values of reactive power, principle of constructing three-phases electromagnetic current transducers, which answers for requirements of compactness, reliability, speed, use modern digital technologies and devises for monitoring reactive power consumption.

1. Introduction

The electromagnetic transducers – transformers of power systems during control in power equipment's and nets of power production, transmission, distribution and consumption processes widely use current transformers, produced by Hall company, based on the principle of converting the magnetic field, created by m.m.f. Classically for transducing of primary electrical current of reactive power to secondary signal use Hall effect. Output signals from current transducers, constructed on the bases of Hall element-effect are very low. Classical one phases primary current transducer can measure both alternating and direct currents, but, as shown from results of our research, classical one phases current transformers can't possibilities measure of value and parameters of magnetic flux of reactive three phases currents of reactive power of consumption of electricity [1-4].

During measure of primary current of reactive power widely use classical one-phases current transformer (TA). This TA is mainly a measure only primary one phases alternating current of the power nets, and their output secondary must be 5 A, when primary current has nominal values and parameter. In classical primary current transformers for control of current mainly consist magnetic core, which have closely forms, primary and secondary winding, installed in magnetic core. They are submitting error of measure more than installed, when equipment working in system with digital devices and have disadvantages from geometrical parameters and power factors [4-6].

As identified from results of research and analysis, the transducer of primary three-phases current to secondary voltage as signal for control, which constructed on the basis of recommended with us

proposals and principles of transforming constructions of transducers sensitivity element - secondary windings, which located in a suitable order between the stators slots, and methodic, which gave possibilities improve accurately measure and control the magnetic flux in the stator of asynchronous motor, have been without any external influences, have high-reliability, fastest, easy distance control and monitoring [3].

2. Method

One of the main problem of control of the three-phases currents of reactive power, which necessary for creating of magnetic values in stator and rotor asynchronous devices is organizing of power supply from single-phase electrical nets, which have non symmetrical and non-sinusoidal values and parameters during creating m.m.f. and magnetic flux[7].

Researching processes of control of reactive power of single-phase power transmission equipment's and sources requires use of phase-shifting elements and three-phase current transducers of reactive power for generate a rotating magnetic field. The method of research of operating and constructing modes of the three-phases electromagnetic current transducers and the dates of construction given in this article. The research results showed, that the signals at the outputs windings of an electromagnetic current transducer depend from types of connection: delta change in proportion to the primary reactive currents supplied to the stator winding of consumers [8].

The construction of electromagnetic transducer of three-phase reactive powers currents to a signal as a secondary voltage given in Figure 1.

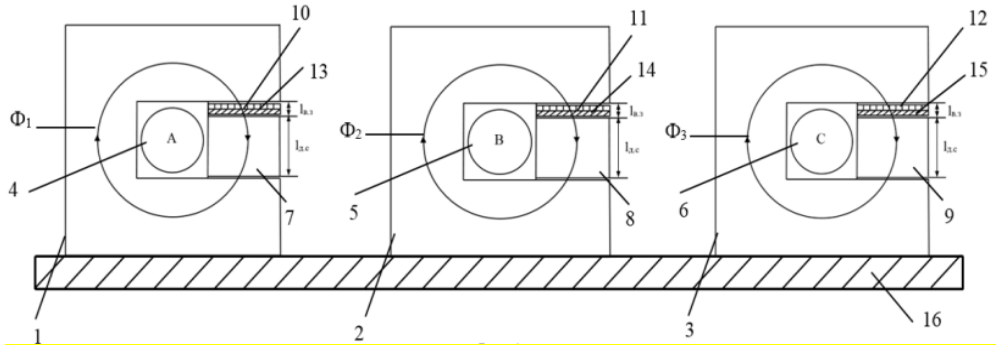


Figure 1. The construction of electromagnetic converter of three-phase reactive currents into a signal in the form of a secondary voltage. *Source:* Compiled by the authors: 1, 2, 3 – magnetic core of three-phase primary current transducers (phases A, B and C); 4, 5, 6 - three-phases conductors of power supply net – primary windings of transducer; 7, 8, 9 – air gaps; 10, 11, 12 - sensitive elements – secondary measure windings, 13, 14, 15 - insulating boards; 16 -isolation basis

The developed device belongs to the field of converter technology and can be used for non-contact monitoring and measurement of reactive power indicators consumed by induction devices.

The task of the electromagnetic converter of three-phase reactive power current is to provide a signal in the form of output voltages of the measuring windings, used as a signal converter about magnetic flux indicators created by the reactive power of electrical energy consumed by induction devices and electrical equipment [9-13].

The problem is solved by the fact that in this device for monitoring and measuring the values and indicators of reactive power, which are the source of magnetic fluxes created by the primary three-phase currents, the measuring windings of the converter are made in the form of a flat structure and independently provide output signals about each phase current of the primary winding of the converter - conductors of the electrical power supply network of induction electrical equipment.

The designs of the measuring windings - sensitive elements of the electromagnetic converter of three-phase reactive power current are presented in Figure 2.

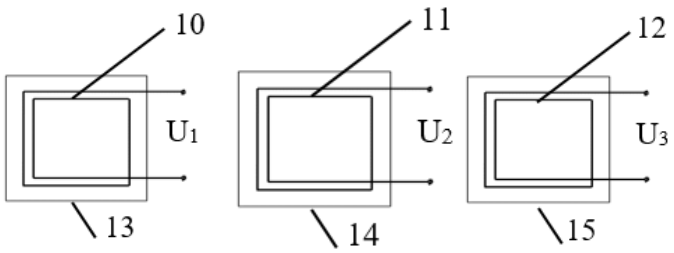


Figure 2. Designs of flat measuring windings - sensitive elements of an electromagnetic converter of three-phase currents of reactive power of electrical energy. *Source:* Compiled by the authors

Output signals in the form of output secondary voltages from the terminals of flat measuring windings based on the values of the primary currents of phases A, B and C of the electrical network - the primary windings of the electromagnetic reactive power current converter are determined as follows [14, 15]:

$$U_1 = 4{,}44 f W_1 \frac{I_A W_1}{R_{\mu 1\Sigma}}$$

$$U_2 = 4{,}44 f W_2 \frac{I_B W_2}{R_{\mu 2\Sigma}}$$

$$U_3 = 4{,}44 f W_3 \frac{I_C W_3}{R_{\mu 3\Sigma}}$$

where: f- AC frequency,

I_A, I_B and I_C - phase currents of the primary windings of the electromagnetic converter of three-phase reactive power current,

W_{11}, W_{12}, W_{13} - number of turns of primary windings (phases A, B and C),

w_1, w_2, w_3 - number of turns of measuring windings,

$R_{\mu 1\Sigma}$, $R_{\mu 2\Sigma}$ и $R_{\mu 3\Sigma}$ - total magnetic resistance of the magnetic part of the stator and the interpolar air gaps of the stator, where the measuring windings are located.

Based on the path of magnetic fluxes created by primary three-phase reactive power currents, the total magnetic resistances of the magnetic part of the induction electrical equipment, where the measuring windings are located, are determined as follows [9, 10, 16]:

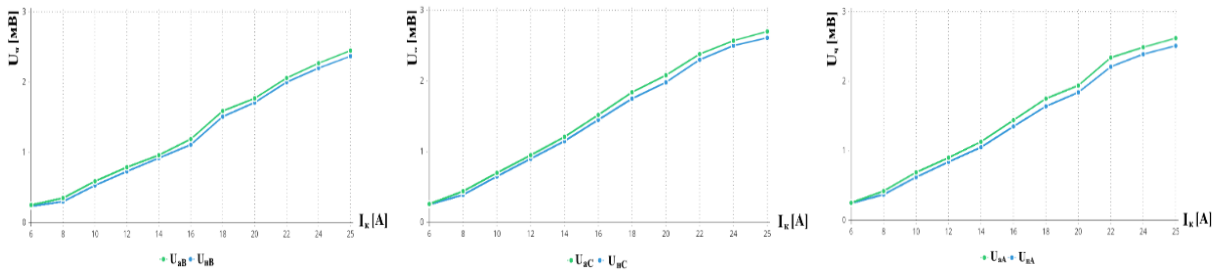
$$R_{\mu 1\Sigma} = R_{\mu 1в} + R_{\mu 1c}$$

$$R_{\mu 2\Sigma} = R_{\mu 2в} + R_{\mu 2c}$$

$$R_{\mu 3\Sigma} = R_{\mu 3в} + R_{\mu 3c}$$

3. Results

Results of research of output voltages from secondary measure windings of primary three-phases reactive power current with values In = 25 A given in Figure 3 a, b, c.



a) b) c)

Figure 3. Results of research of output voltages from secondary measure windings of primary three-phases reactive power current with values: In = 25 A (a – in phase A, b – in phase C, c – in phase C. *Source:* Compiled by the authors

The leads of the three phases reactive currents electromagnetic transducer, which used during research, can be connected in a form star and delta connection, and they located in the air gape which determine

by value and parameters of output signal from lead of electromagnetic transducer value of reactive power as a output secondary voltages (Figure 3).
During research used the next values and parameters power use devices: nominate active power P = 250 Wt [5]. The number of secondary windings providing output signals of the three phases reactive currents of the electromagnet transducer is w = 10 windings [9, 10, 17].
The analysis of the error of measure and accuracy indicators of the electromagnetic three-phases reactive power currents transducer mean square deviation and entropy error are found according to the probability distribution law [9].
For an electromagnetic transducer of three-phases currents of reactive power error of measure determine as:

$$\sigma_{\Sigma} = \sqrt{\sigma_1{}^2 + \sigma_2^2 + \sigma_3^2 + \sigma_4^2} = \sqrt{0,1^2 + 0,1^2 + 0,1^2 + 0,1^2} = 0,2$$

$$\Delta_1 = K_E \cdot \sigma_{\sum} = 2,07 \cdot 0,2 = 0,414$$

Based on the results of the research, the entropy errors of the single-phase electromagnetic current transducer were determined. Based on the results, it can be concluded that specified entropy error for control and management devices is Δ= 0,5. This electromagnetic current transducer offer is accurate, fast, compact, and the ability to be remotely controlled.

4. Conclusion

Based on the results of research and analysis, the following conclusions were reached:
- The implementation of the measuring windings of the converter makes it possible to provide the normalized output voltages (5 V) required by digital control and measurement devices, which ensures increased quality indicators of output signals in the form of secondary voltages necessary for monitoring and managing reactive power sources, helping to ensure high-quality indicators of electrical energy.
-determine a possibilities of measuring sensitive rings based on an individual connection, star, triangle, which allows the distribution of magnetic quantities and parameters created in the magnetic elements of the output voltage of a current transducer, to evaluate the asymmetry and non sinusoidal indicator of the reactive power.

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