

Research of three phases electromagnetic current transducers for control of reactive power consumption of induction motors powered by solar panels

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Abstract. In the world have been great importance to use of solar energy sources to ensure uninterrupted and high-quality electricity needs of consumers. As known, that 60-70% of generated electricity is consumed by asynchronous motors. In asynchronous motors, active power is consumption for useful activities, and reactive power consumption for creation of magnetic values – magneto moving force and magnetic flux. The issues of control of reactive power consumption and improving parameters of current transducers, which use in processes of control, request developing of new types digital technologies and devices of measure systems and implementing them in practice are considered relevant. In this article given results of research and implementation new three phases current transducers which using in processes of control of reactive power supply of induction motors, generated by solar panels, which have possibilities control and evaluate asymmetrical and non-sinusoidal parameters of reactive power. Explained the results of research of principles of constructing three phases electromagnetic current transducers, meeting with requirements of compactness, reliability, speed and uses of digital technologies during research of their static and dynamic operating modes.

INTRODUCTION

The global depletion of oil, gas and other primary energy sources requires the gradual implementation of solar, wind and bio energy resources, including in Uzbekistan, to save natural resources, environmentally friendly and cheap types of energy. In this case, for widely use of modern power systems for control of power production, transmission, distribution and consumption processes use electromagnetic transducers, produced by the Hall company, based on the principle of converting the magnetic field, created by magneto moving forces and primary three phases currents of power supply systems. Output signals from current transducers in the Hall element are very low. Classical primary of the one phase current transducer can measure both alternating and constant 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 the stator windings of an asynchronous motor [1].

Today, for measure of primary one phases current of asynchronous motor of industries widely used classical current transformer (TA). This current transformer is mainly a measure only primary current of the power nets, and their output current from secondary winding have value is 5 A, when primary current is nominal parameter. In classical power transformers for control of current mainly uses current transformer consist magnetic core, which have closely forms and installed between primary winding and a secondary winding, which they are submit error of measure more than installed, when the are working in system digital devices and disadvantages, connected with geometrical parameters, and power consumption [2].

As identified from results of research and analysis, the transducer of primary three phases current of stators windings of asynchronous motor, supplied by single-phases source as renewable energy sources (solar panels, wind

power generators, accumulators and etc.) 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, and other aspects are preferred [3].

EXPERIMENTAL RESEARCH

Researching asynchronous motor supplied from a single-phase power grid generated by solar panels, the asynchronous motor requires use of phase-shifting elements and three phase currents of reactive power in the stator windings to generate a rotating magnetic field.

One of the main problem of generation and control of three phases currents of reactive power, which necessary for creating of magnetic values in stator and rotor asynchronous motors are on power supply them from single-phase electrical networks with renewable energy sources and solar panels, which produce only active power of electricity.

The circuit for remote measurement, monitoring and control of reactive power consumption of an asynchronous motor, powered by a single-phase nets of a solar panel energy source with electromagnetic current transducers presented in figure 1.

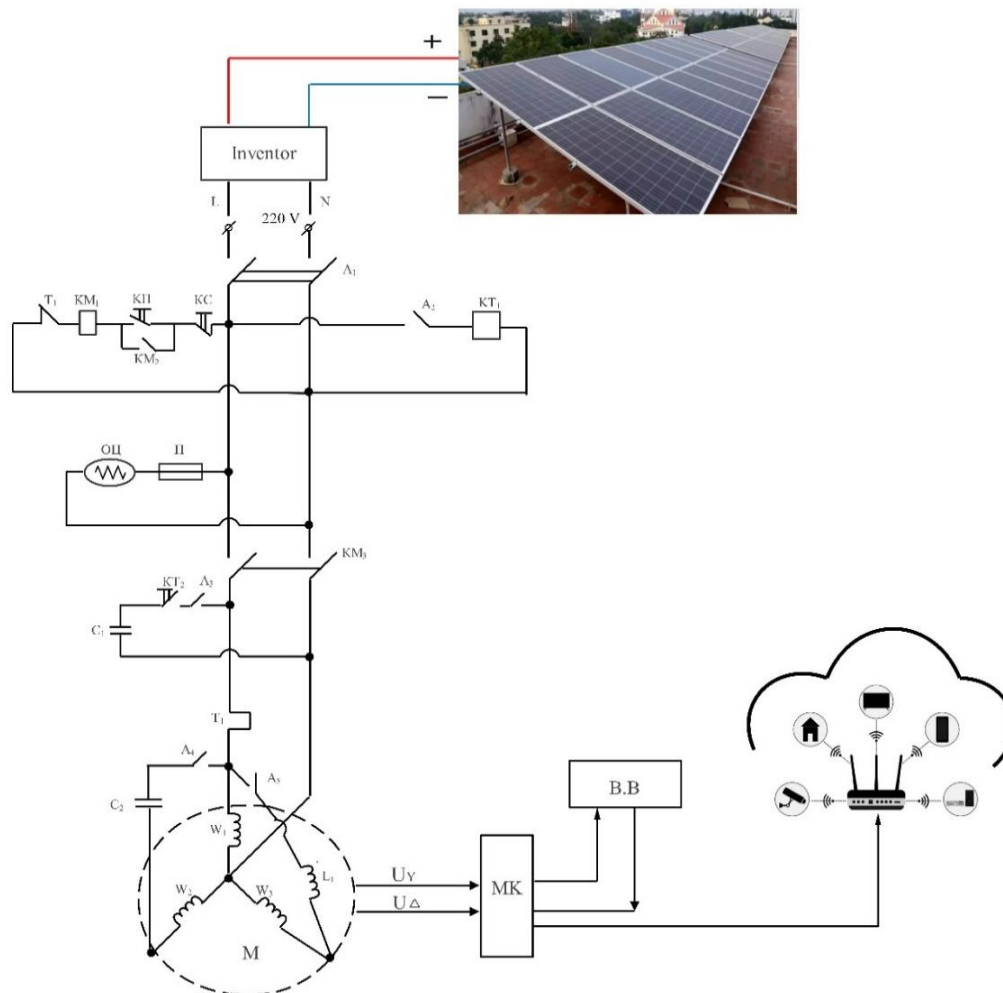


FIGURE 1. Scheme for distance measure, monitoring and control of reactive power, consumed by an asynchronous motor powered from a single-phase nets of power source with solar panel, which use a control and regulating with electromagnetic current transducer of three phases currents of reactive power of electricity.

where: L - electrical wire from renewable power sources as a solar panels, Kstart - start button, Kstop -stop button, A1, A2, A3 - circuit breakers, KM1, KM2, KM3 - magnetic starter and its contacts, KT- time relay, T1 - thermal relay, C1, C2 - Starting and operating capacitor banks, L1 - phase-shifting inductive coil, O-oscilloscope, P - fuse, W1, W2, W3 – number of the stators windings of asynchronous motor.

Single-phase induction asynchronous motors which powered by solar panels provide power ratings which different from three-phase motors during energy consumption on various modes. At the same time, main and phase-shifting starting capacitors and inductors allow a single-phase asynchronous motor with a squirrel-cage rotor to operate in the appropriate operating modes [4].

Research of operating and constructed modes of an asynchronous motor equipped with working and phase-shifting capacitors and phase-shifting inductive elements provided by a solar energy source was carried out on the basis of an three phases electromagnetic current transducers and the data obtained from it. The research results showed, that the signals at the outputs of the windings of an electromagnetic current transducer connected by a star and a delta change in proportion to the primary reactive currents supplied to the stator winding of an asynchronous motor [5].

The construction of electromagnetic converter of three-phase reactive currents to a signal in the form of a secondary voltage given in figure 2.

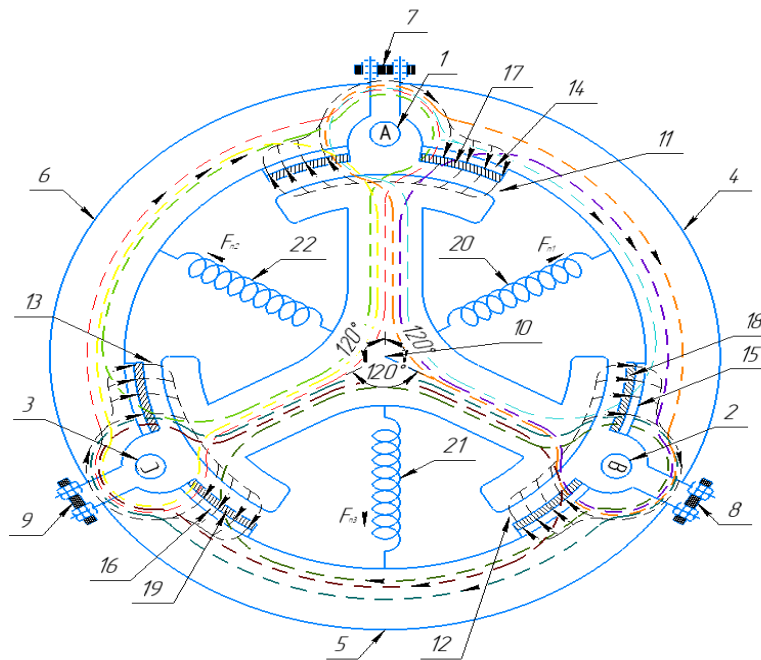


FIGURE 2. The construction of electromagnetic converter of three-phase reactive currents into a signal in the form of a secondary voltage.

where: 1, 2, 3 – three-phase primary current conductors (phases A, B and C); 4, 5, 6 - parts of the magnetic conductor; 7, 8, 9 - fasteners; 10 - Y - shaped internal magnetic conductor; 11, 12, 13 – air gaps; 14, 15, 16 - the location range of the sensors; 17, 18, 19 – sensitive elements; 20, 21, 22 – magnetic conductor.

RESEARCH RESULTS

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

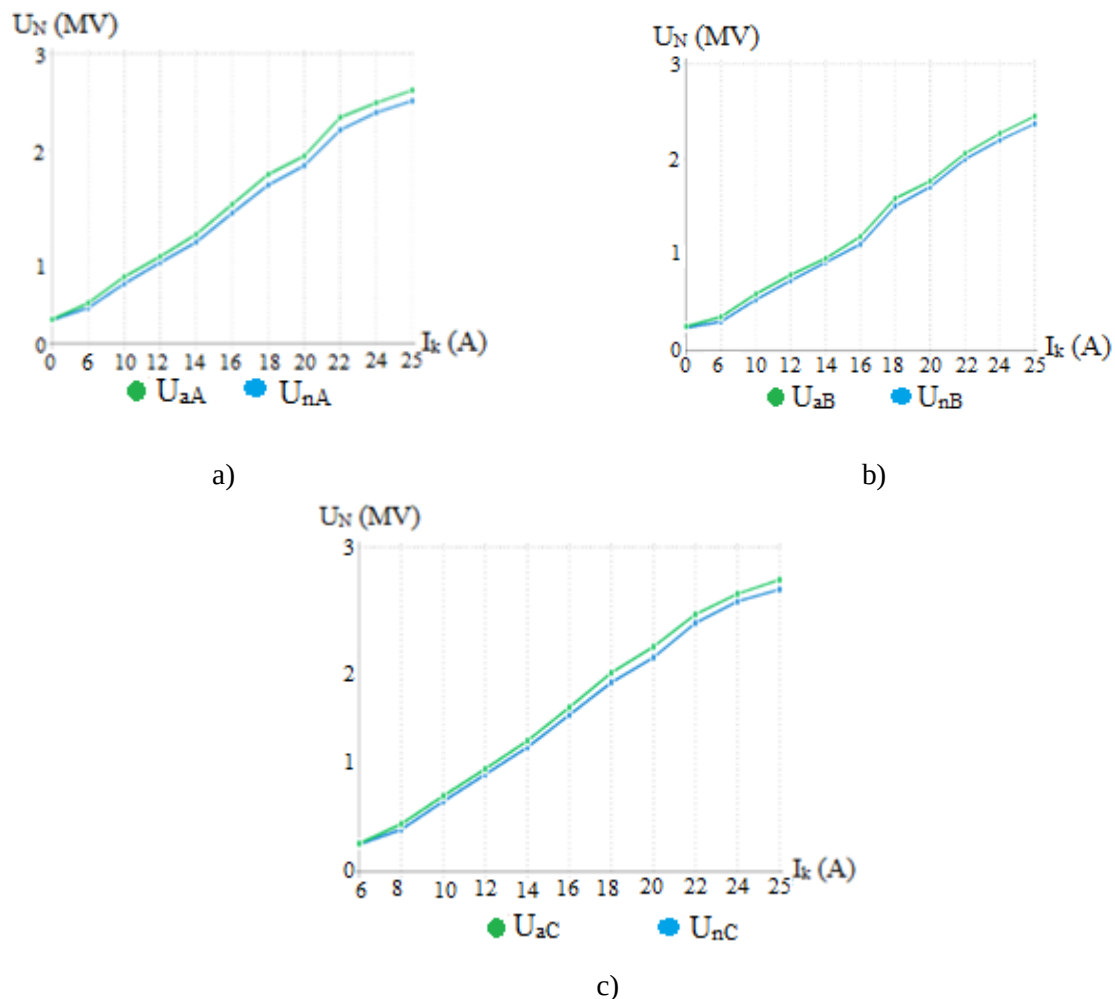


FIGURE 3. Results of research of output voltages from secondary measure windings of primary three-phases reactive power current with values: $I_n = 25$ A (a – in phase A, b – in phase B, c – in phase C).

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 space between the stator slots, according to the location of the stator coils, and can connected in parallel or separately, which determine by value and parameters of output signal from lead of electromagnetic transducer value of reactive power as a output secondary voltages (Figure 4)

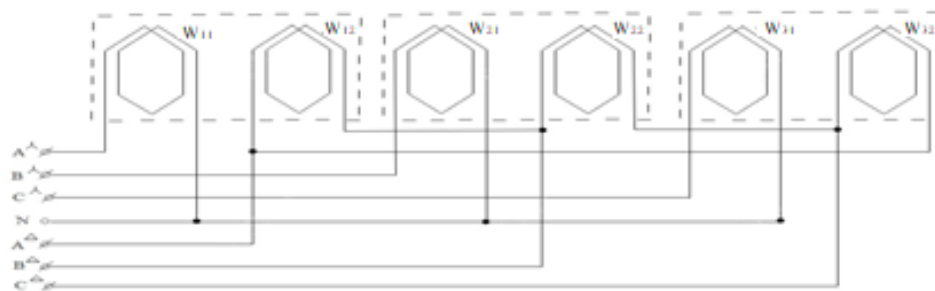


FIGURE 4. Diagram of connection of outputs secondary windings of the three phases reactive currents electromagnetic transducer.

During research used the next values and parameters of asynchronous motor: nominate active power $P = 250 \text{ Wt}$, this value carried out on the basis of an asynchronous moto. the type 4A63 [5]. The number of secondary windings providing output signals of the three phases reactive currents of the electromagnet transducer, which connected in the form of a triangle is $w = 140$ windings.

When asynchronous motor powered by electricity generated by a solar panel renewable energy source with single-phase nets of power source, output values corresponding from each connections group of were obtained different quantities and qualities due to different convention of sensitivities of secondary windings of electromagnetic transduce and as a results of research it was possible to determine the resulting asymmetry and non-sinusoidal in the phases of reactive power.

It has been proven that the signals at the outputs of star- and delta-connected coils of an electromagnetic current transducer differ from each other by $\sqrt{3}$ depending on the connection of the coils.

The analysis of the error and accuracy indicators of the asynchronous motor electromagnetic current transformer supplied with energy produced by single-phase solar panels. Mean square deviation and entropy error are found according to the probability distribution law [7].

For an electromagnetic current transducer with a delta-connected sensing element ring a error determine as:

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

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

for star-connected electromagnetic current transducers:

$$\sigma_{\Sigma} = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \sigma_4^2} = \sqrt{0,1^2 + 0,1^2 + 0,1^2 + 0,05^2} = 0,18$$

$$\Delta_2 = K_E \cdot \sigma_{\Sigma} = 2,07 \cdot 0,18 = 0,392$$

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

CONCLUSIONS

-one of the main results of research are constructed devices for automated control and monitoring, models and algorithms of improving dynamic characteristics of renewable energy sources, which received for them patent for invention from the Intellectual Property Agency of the Republic of Uzbekistan for electromagnetic transducers “Current to Voltage Transducer” (No. IAP 06646 - 2021).

-created model of magneto moving force of one-, two- and three-phase currents transducers for automated control and monitoring system based on IoT, which submit possible increase the sensitivity of the transducer up to 6 times, automated monitoring system for renewable energy sources based on electromagnet transducers, a microcontroller unit and IoT devices made it possible to reduce the time for maintenance and operation of power supply sources by 7-8%.

-constructed the structure of automated monitoring of sources of hybrid power supply, the database and the format of their presentation, as well as the wireless transducers nets of the automated control and monitoring system based on IoT. As a result of scientific research, through the use of a patent for an invention, created devices and developed models, algorithms and software, the reliability of monitoring devices has been increased, and economic efficiency due to saving energy and resources amounted to 2-3% per year;

-due to create of high accuracy of systems and continuous operation of devices due to control monitoring and forecasting of electricity consumption based on IoT, an increase in efficiency of 4-5% is expected;

-due to the timely detection of faults in hybrid energy, sources of supply of mobile communication base stations and operational maintenance, it was possible to predict the power consumption of mobile communication base stations with an accuracy of 97% and increase the efficiency of the system by 3-4%.

-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 asymmetry of the sinusoidal indicator of the reactive power of an asynchronous motor. The research of device parameters allows normalize values of output signal in the form of electrical voltage (5 V). From the results of the research dynamics characteristic determine, that the time of stability of the output signals of the electromagnetic current converter is $t = 0,05$ seconds.

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