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Three-phase asynchronous motor three-phase current converter for the research of electromagnetic processes

Zailobiddin Boixanov; Ilhomjon Siddikov; Jasurbek Nizamov; Sultanbek Abdurahmonov

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Three-phase asynchronous motor three-phase current converter for the research of electromagnetic processes

Zailobiddin Boixanov [1, a)], Ilhomjon Siddikov [2], Jasurbek Nizamov [1], Sultanbek Abdurahmonov [1]

[1]Andijan machine-building institute, Andijan, Uzbekistan
[2]The Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent, Uzbekistan

[a)] Corresponding author: zaylobiddin1992@gmail.com

Abstract. Currently, extensive scientific research work is being carried out to ensure energy resource saving all over the world. We know that the issues of high-quality and reliable supply of electricity to consumers are also urgent. In particular, 60-65 percent of electricity is consumed by asynchronous motors in industrial enterprises, which raises the issue of using them in an energy-efficient manner. In this article, a scientific opinion, conclusion and about the structure, model, static and dynamic characteristics of the three-phase current transformer designed to control and control the electric and magnetic processes generated in the stator coil and rotor coil of asynchronous motors are presented. results are presented. In this, the effect of the proposed three-phase current transformer on electric and magnetic processes in the stator coil was studied.

INTRODUCTION

Electricity is the main energy source in today's production, consuming 60% of all electricity produced. Asynchronous electric drives with short-circuited rotors are the majority in industrial enterprises, the use of adjustable asynchronous electric drives is one of the most effective ways to reduce energy consumption to a minimum, fulfill the necessary technological requirements, and solve energy saving issues [1].

Classical methods for calculating complex magnetic circuits are very approximate and do not always allow to take into account the characteristics of the magnetic conductors of the current transformers, which provide the transformation of the primary load current into voltage in the control and management systems of the operation modes of asynchronous motors. There are a number of calculation methods using modern computer systems, which provide sufficient accuracy of the results, allow taking into account the influence of various factors, properties of materials, etc., but the calculations are complicated by their large volume. Therefore, it is desirable to improve calculation methods, in particular, mathematical models of switching chains.

EXPERIMENTAL RESEARCH

Topological methods of analysis and calculations are based on the representation of current-to-voltage electromagnetic converter circuits in the form of connected graphs. The application of such methods of analysis of switching circuits is related to the wider use of EHMs, improvement and further development of current transformers under investigation, improvement of their parameters and reduction of the sizes of existing current transformers. Effective use of exposures, in turn, requires the development of more applied and simpler algorithmic methods and models for conducting research and calculations [3].

The process of converting the high-harmonic currents of the asynchronous motor stator 1,3,5 into output signals in the form of secondary rated voltage, and the modeling and research of the devices and transformers involved in this process are carried out on the basis of models and algorithms [2].

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When an asynchronous motor is connected to a 1st, 3rd, 5th high-harmonic source, a model of the process of converting the mains voltage U_A $(f_1f_2f_3)$ into the mains magnetic driving force F_0 $(f_1f_2f_3)$ is created (Fig. 1).

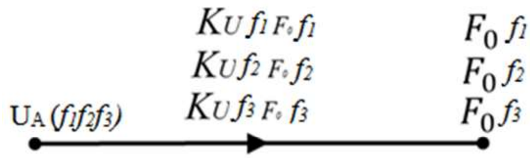

FIGURE 1. Model of the process of changing the mains voltage F_σ $(f_1f_2f_3)$ to the main magnetic driving force

A model of the process of transformation of the stator winding current F_σ $(f_1f_2f_3)$ of the asynchronous motor $I_A(f_1f_2f_3)$) into the magnetic driving force is created (Fig. 2).

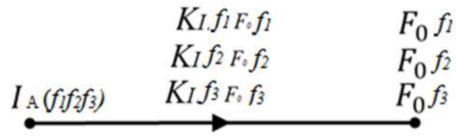

FIGURE 2. Model of the process of transformation of the stator current $F_\sigma(f_1f_2f_3)$ into the magnetic driving force.

F_0f_1, F_0f_3, F_0f_5; $F_\sigma f_1$, $F_\sigma f_3$, $F_\sigma f_5$, of the magnetic switching element; An analytical representation of the relationship between magnetic driving forces and primary electric current and voltage $I_A(f_1f_2f_3)$, $U_A(f_1f_2f_3)$ is made:

$$F_{0f_1} = KU_{Af1}, \qquad F_{\sigma f1} = KI_{Af1}$$

$$F_{0f_3} = KU_{Af3} \qquad F_{\sigma f3} = KI_{Af3}$$

$$F_{0f_5} = KU_{Af5} \qquad F_{\sigma f5} = KI_{Af5}$$

As a result of the passage of currents I_1, I_2, I_3 from the stator windings U_1-U_2, V_1-V_2, W_1-W_2 of a three-phase asynchronous motor, Φ_1, Φ_2, Φ_3 which are symmetrical in the stator core, crossing the measurement windings u_1-u_2, v_1-v_2, w_1- w_2 head and $\Phi\sigma_1$, $\Phi\sigma_2$, $\Phi\sigma_3$ generate scattered magnetic currents [3,8].

$$\begin{cases} \Phi_1 = \dfrac{1}{4{,}44 f w_1} \cdot U_A; \\ \Phi_{13} = \dfrac{1}{4{,}44 \cdot f_3 w_1} U_A; \\ \Phi_2 = \dfrac{1}{4{,}44 f w_2} \cdot U_B; \\ \Phi_{23} = \dfrac{1}{4{,}44 \cdot f_3 w_2} U_B; \\ \Phi_3 = \dfrac{1}{4{,}44 f w_3} \cdot U_C; \\ \Phi_{33} = \dfrac{1}{4{,}44 \cdot f_3 w_3} U_C; \end{cases} \qquad \begin{cases} \Phi_{\sigma 1} = \dfrac{L_{\sigma 1} \cdot I_1}{w_1}; \\ \Phi_{\sigma 13} = \dfrac{L_{\sigma 13} \cdot I_{13}}{w_1}; \\ \Phi_{\sigma 2} = \dfrac{L_{\sigma 2} \cdot I_2}{w_2}; \\ \Phi_{\sigma 23} = \dfrac{L_{\sigma 23} \cdot I_{23}}{w_2}; \\ \Phi_{\sigma 3} = \dfrac{L_{\sigma 3} \cdot I_3}{w_3}; \\ \Phi_{\sigma 33} = \dfrac{L_{\sigma 33} \cdot I_{33}}{w_3}; \end{cases}$$

From the analytical expressions and graphs given in the study of the dynamic characteristics of the dependence of the asynchronous motor stator currents on the converter output voltages, we conclude that after the asynchronous motor is connected to the U1 voltage network, depending on the motor parameters, the current converter output voltages are in the time interval t=0,02–0,03 s reaches its steady state [11].

Current to voltage determined based on the conducted experimentstransformer 2– main winding in stator wedges 3 – main winding and 5 – additional winding located between the wedges 4 – additional winding, consisting of 1 – common magnetic core with main stator windings, 6 – heating zone on the surface of the steel part of the electric motor rotor due to magnetic losses around the circle (fig-3). The measuring instrument is placed in such a way that the output value in the form of voltage is obtained from the measuring instrument under the influence of the main and stray magnetic currents generated in the stator part [5, 10-18].

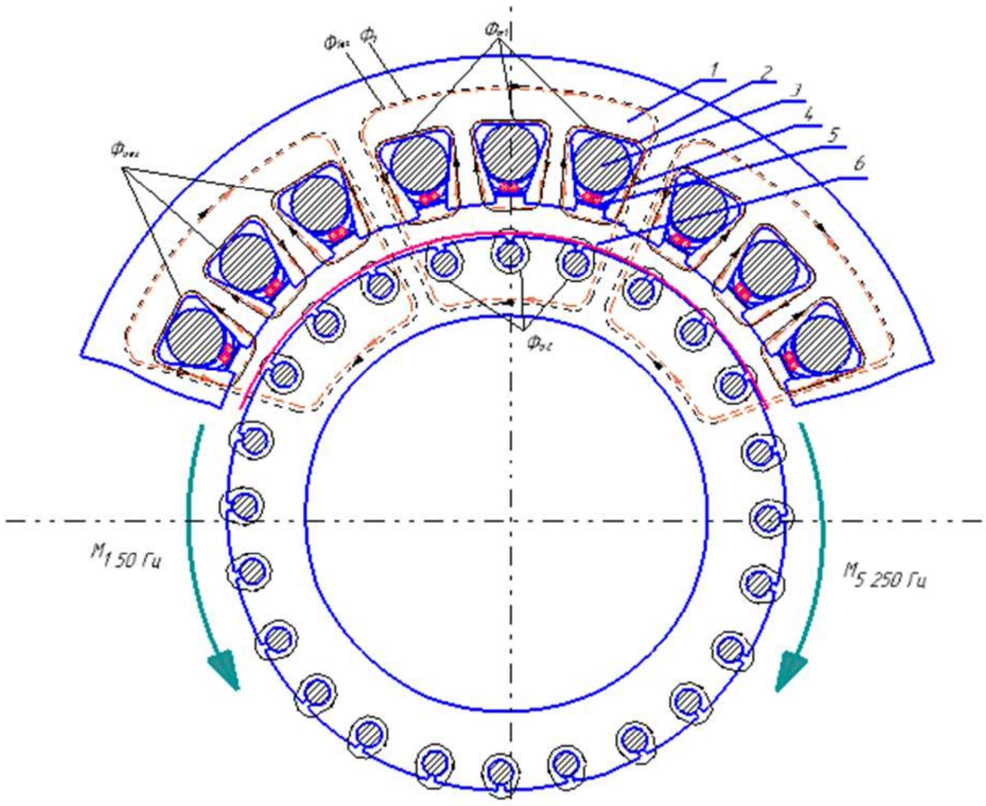

FIGURE 3. Location of three-phase main and higher harmonics in the asynchronous motor stator part of the current-to-voltage converter and appearance of magnetic fluxes.

RESEARCH RESULTS

The parameters of the electric motor installed on the 5.5 kW press-forging equipment for modeling are as follows:

P – 5,5 кВт, n – 1500 rot/min, U – 380/220 V, f – 50 Hz
Rs – 1,124 Ом, Ls – 0.004246 Ом, Rr – 1.0145 Ом
Lr – 0.004245, Lm – 0.1252, J – 0.01801 кg*м2
F – 0.00217 Н*м*с, p – 2

The experimental results of determining the main electromagnetic processes in the stator winding of a three-phase asynchronous motor are as follow [10].

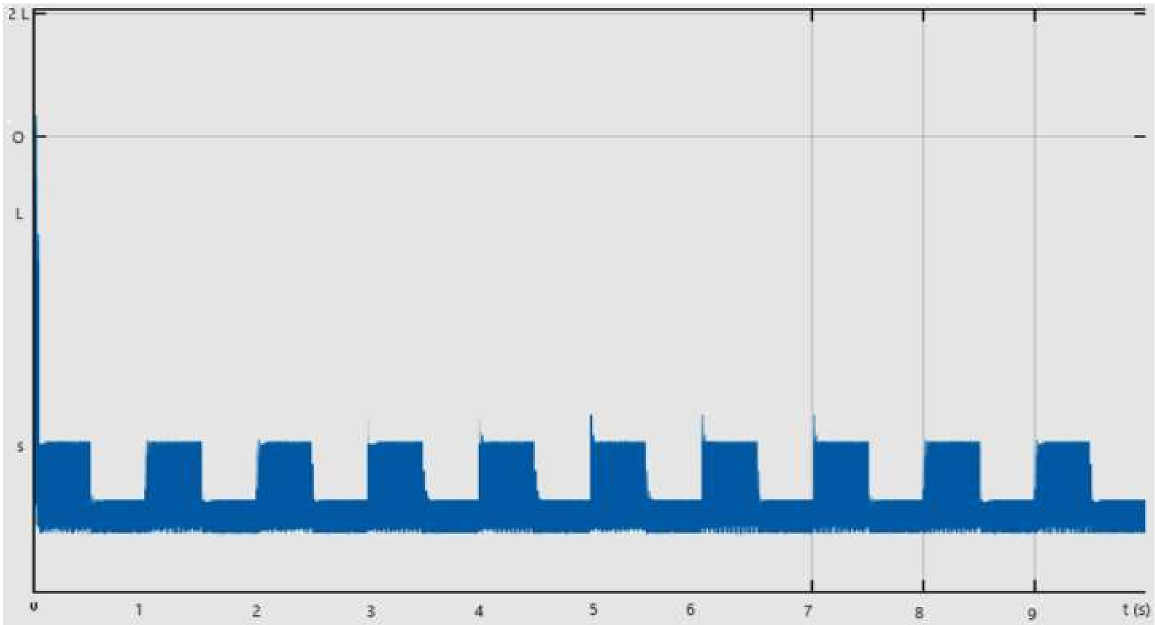

FIGURE 4. Capacitance of the capacitor required by the received signal, μF

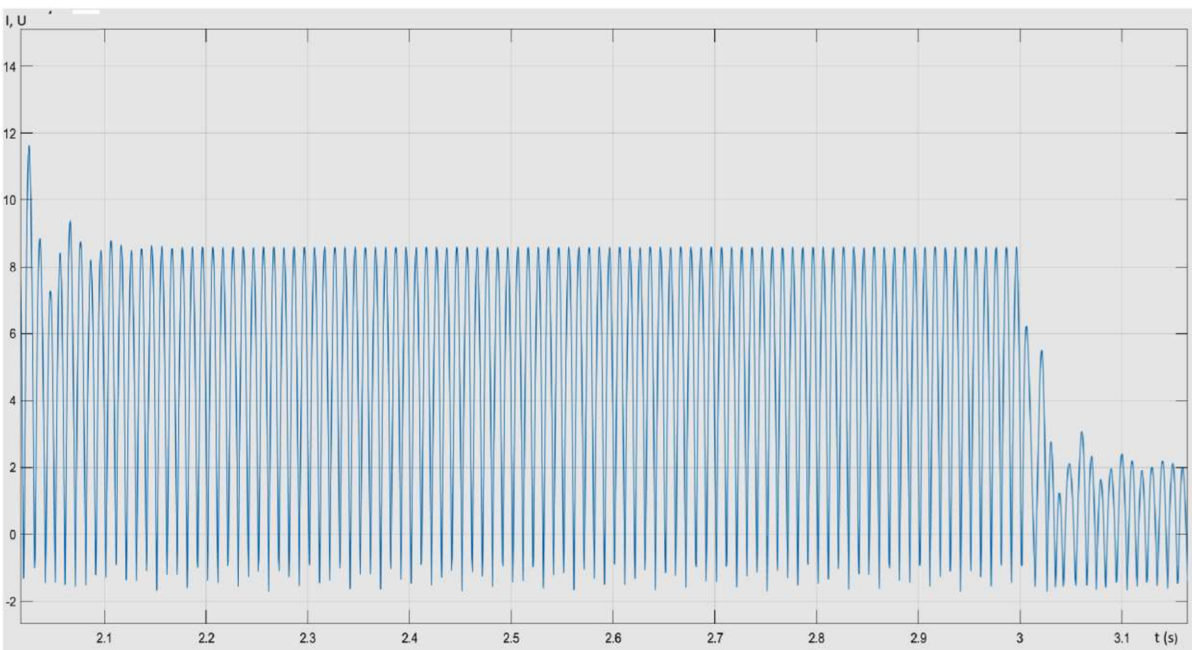

FIGURE 5. output signal from the current converter

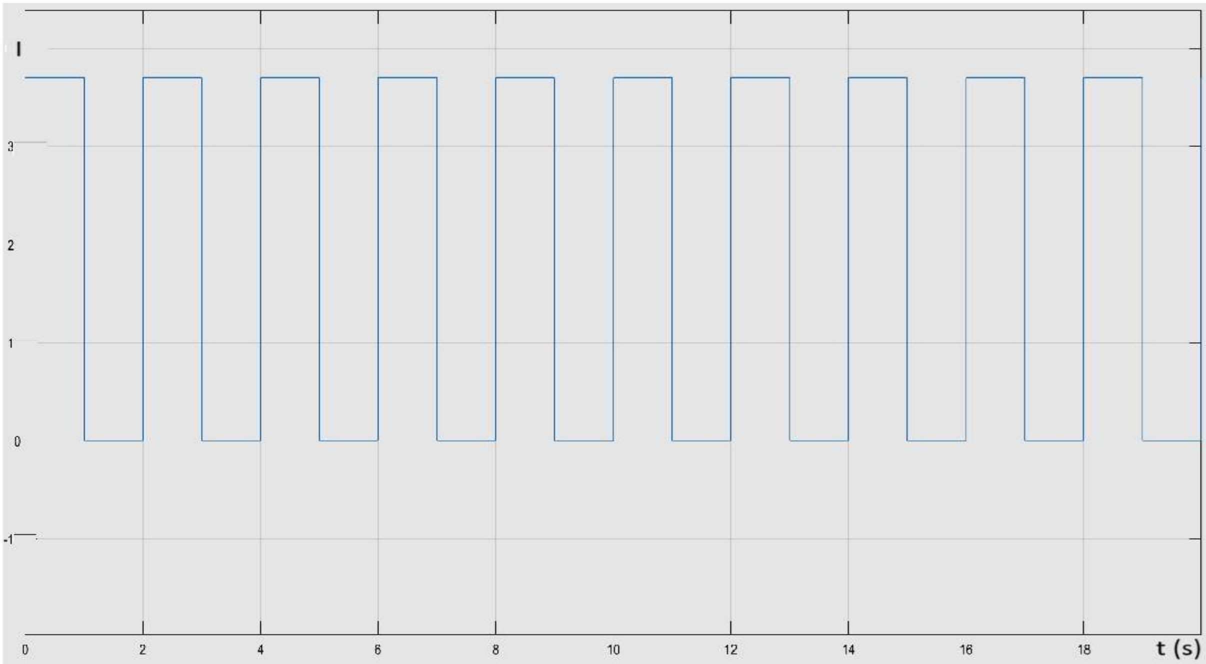

FIGURE 6. Variation of stator currents during loading, phase A

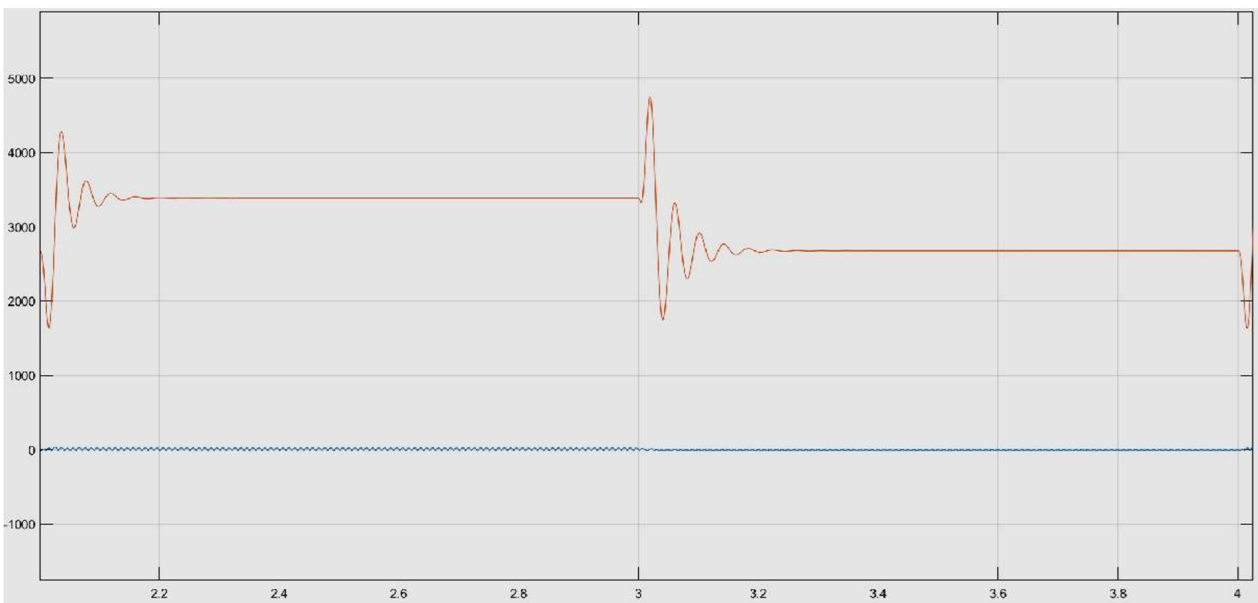

FIGURE 7. Variation of stator currents during noload

CONCLUSION

It is possible to use a converter to convert stator main and high-harmonic currents into voltage when creating energy-saving electrical circuits for consumer - asynchronous motor.The structure of remote monitoring of electricity consumption, diagnosis, information exchange, database and data format was determined based on the control algorithm for the consumer - asynchronous motor, signal converters and microcontrollers.

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