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Electromagnetic compatibility of systems autonomous voltage inverter - induction motor with a power source

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Abstract

For electric power industry in railway transport, the problem of "clogging" of electrical networks with conductive conjugacy with the consumer has become (valve inverters and other nonlinear loads are the source of higher harmonics and subharmonics of the current, i.e. harmonics with a frequency lower than the frequency of the supply voltage). Within the framework of this article, we will limit ourselves to: consideration of optimal systems of autonomous voltage inverter - induction motor (AVI – IM); for estimate the filter parameters in the system of AVI - IM, we determine the ripple coefficient and the amplitude of the ripple of the input current; Consider the question of conductive coupling of AVI - IM with a power source; consider pulsation reduction methods and increasing the frequency of the input current.

Keywords: Autonomous voltage inverter; Induction motor

1. Introduction

One of the most promising areas for the development of modern electric rolling stock is the use of the "autonomous voltage inverter - induction motor" (AVI-IM) system in the traction electric drive. It should be noted

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that among the many options of the three-phase system the most optimal, there is three-level voltage inverter used as AVI [1]. The system of three-level AVI with three-phase IM is shown in Fig. 1.

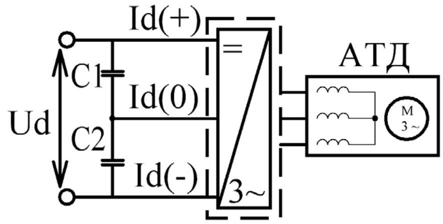

Fig. 1. The system of three-level AVI with three-phase IM.

In the proposed AVI-IM system to increase the energy performance of the traction motor as a whole (in comparison with the three-phase systems on the two-level AVI), it is possible to form a phase voltage curve with an increased content of first harmonic [2].

Present the curve with the following constant parameters (see Fig. 2): $\gamma=\pi/12$, $\delta=\pi/4$ and ($U=0.7638*U_a$, $U_1=0.7531*U_a$) the distortion factor of the AVI output voltage is 0.986, and the harmonic factor is 0.166. The phase IM currents for this type of system are shown in Fig. 3.

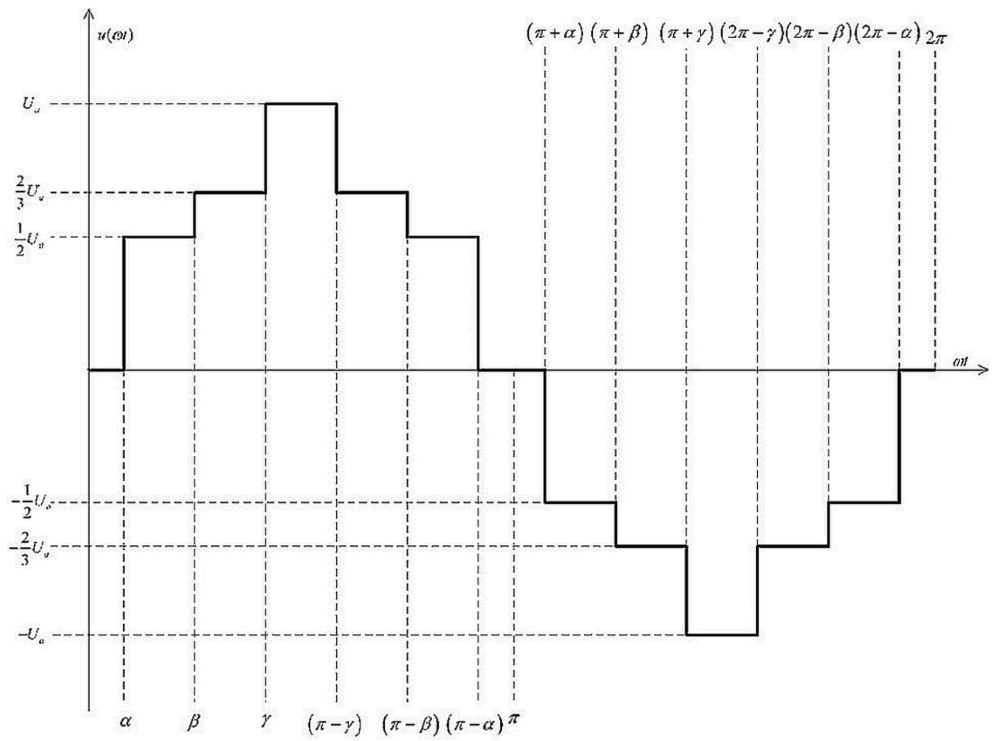

Fig. 2. Curve of supply voltage of the improved form.

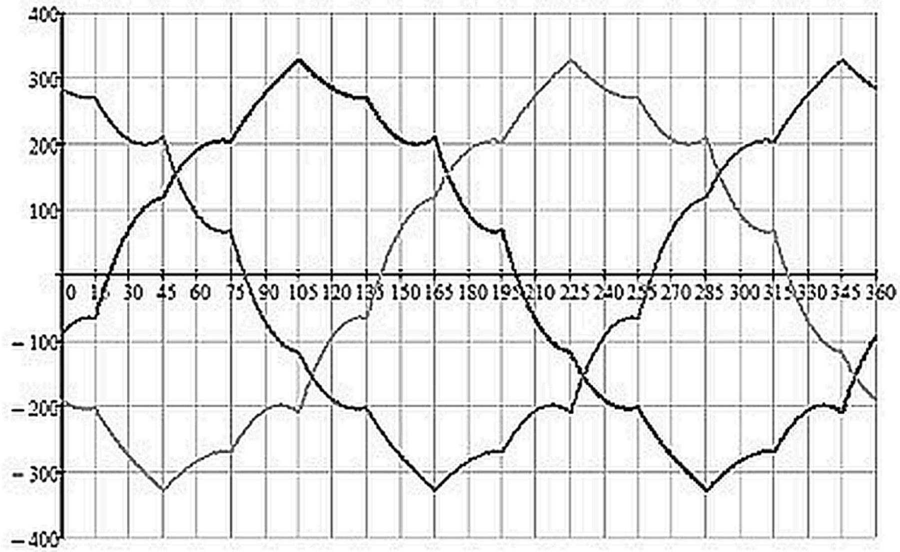

Fig. 3. IM phase currents curves.

The analytical instantaneous value of the input current consumed from the power source is described as:

$$i_{d1}(\Theta)_1 = \begin{cases} i_C(\Theta) if\ 0 \le \Theta \le \pi/12;\ i_B(\Theta) if\ \pi/12 \le \Theta \le \pi/4;\ i_A(\Theta) if\ \pi/4 \le \Theta \le 5\pi/12;\ i_A(\Theta) if\ 5\pi/12 \le \Theta \le 7\pi/12 \\ i_A(\Theta) if\ 7\pi/12 \le \Theta \le 3\pi/4;\ -i_C(\Theta) if\ 3\pi/4 \le \Theta \le 11\pi/12;\ i_B(\Theta) if\ 11\pi/12 \le \Theta \le 13\pi/12 \\ i_B(\Theta) if\ 13\pi/12 \le \Theta \le 5\pi/4;\ i_B(\Theta) if\ 5\pi/4 \le \Theta \le 17\pi/12;\ -i_A(\Theta) if\ 17\pi/12 \le \Theta \le 19\pi/12 \\ i_C(\Theta) if\ 19\pi/12 \le \Theta \le 7\pi/4;\ i_C(\Theta) if\ 7\pi/4 \le \Theta \le 23\pi/12;\ i_C(\Theta) if\ 23\pi/12 \le \Theta \le 2\pi \end{cases} \quad (1)$$

2. Two-block system in asynchronous mode of control

The best way to connect the proposed AVI - IM system on ERS is a scheme, where each IM is connected to an individual AVI, which work in asynchronous mode, namely with a shift of the control angle relative to each other. In this case, the current in «0» bus vanishes, as the currents in «0» bus of the first and second AVIs are in antiphase and compensate each other. The imbalance of these currents will occur only in case of a mismatch of loads of IM [3]. When operating in asynchronous mode of this system, the angles of control of the AVI of the first and second blocks are shifted by 60 ° relative to each other. The variant of connecting two systems with three-level AVI - IM, as a two-block system in asynchronous mode of control, is shown in Fig. 4.

3. Four-block system in asynchronous mode of control

Conducting further research on the operation of systems with three-level AVI - IM, we can propose the development of a method to improve the connection of a bipolar power source with the AVI - IM system. To do this, we will create a four-block system, which will consist of two two-block AVI – IM systems, discussed earlier and working in asynchronous mode, namely, with a shift in the control of AVI this systems relative to each other.

In this case, the current in «0» bus vanishes, as the currents in «0» bus of the first and second blocks of AVI - IM systems are in antiphase and compensate each other. The currents in the «+» and «-» bus are summed, forming input currents with a high pulsation frequency and a smaller pulsation amplitude. When operating in asynchronous mode of this system, the angles of control of the AVI of the first and third, second and fourth blocks are offset by 30 ° relative to each other. Scheme of three-level AVI with three-phase IM is shown in Fig. 5.

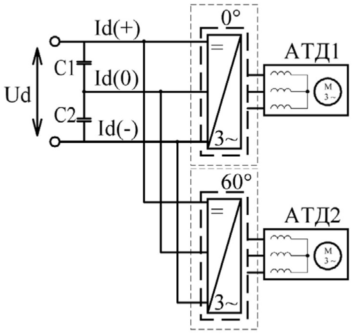

Fig. 4. The variant of connecting two systems with three-level AVI - IM, as a two-block system in asynchronous mode of control.

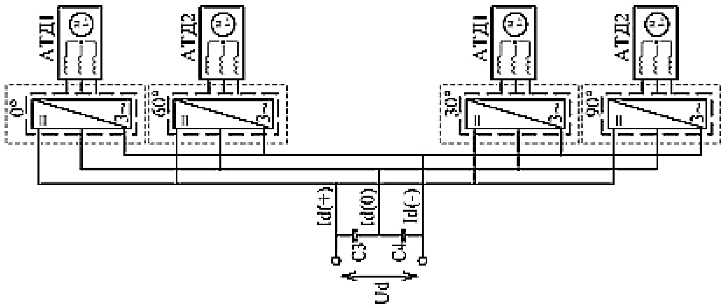

Fig. 5. Scheme of two-level AVI with two-phase IM.

The ripple factor 0.14 and the ripple amplitude 277.76 of the input current in «+» bus, the ripple frequency of the input current relative to the frequency of the supply voltage is a multiple of 12.

4. Conclusion

The proposed method of compensating higher harmonics of input currents to a system with a three-level AVI - IM allows to significantly improve the harmonic composition of the total input current and the resulting pulsation coefficient values. A comparative analysis of the algorithms of a single, two-block and four-block system, which includes systems with three-level AVI - IM, allows to conclude that the asynchronous control of single blocks produces the effect of mutual compensation of all induced electromagnetic interference during their operation, and therefore compensation of higher harmonics of input currents of this blocks, what is achieved a significant improvement in the ripple factor of the input current. The results of the study allow us to conclude that the proposed AVI control method appropriate use to solve the issue of improving conductive coupling with any number of phases of both AVI and IM.

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