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EXPERIMENTAL STUDY OF STATIC AND DYNAMIC CHARACTERISTICS OF TORQUE REGULATION ALGORITHMS FOR TRACTION ASYNCHRONOUS ELECTRIC DRIVES

Results of comparative experimental testing of frequency and vector control algorithms of asynchronous motor torque are presented. The advantages of vector control systems application in electric drives of vehicles are shown.

Key words: *asynchronous traction electric drive, torque vector control, mechanical characteristics.*

Introduction. Rapid development of the infrastructure of large cities in Ukraine, observed in the last few years, forms a demand for considerable number of new urban electric transport units such as: trams, trolley buses, electric buses and hybrid buses. Following current trends, most traction electric drives of the considered vehicle operate on alternating current using asynchronous motors (AM). Due to the lack of domestic asynchronous electric drives, the demand of internal market is covered by import, which adversely affects the price of mobile units. That is why, the execution of the work, aimed at creation of serial asynchronous traction electric drive with dynamic and power characteristics that are not inferior to existing foreign analogues is of great importance.

The **aim** of the given paper is to present the results of experimental studies of static and dynamic characteristics of the systems of frequency and vector torque control of asynchronous motors in terms of their usage for traction applications.

Materials of research. Experimental testing of AM torque control algorithms was carried out on the installation, comprising two AM, rated for 2.2 KW (nominal torque 15 Nm), their shafts being connected mechanically; photo-pulse speed sensor with the resolution of 1024 pul./rev., power semiconductor converter with self-contained voltage inverter on IGBT keys; controller [1] on the base of 32-bit digital signal processor with floating point, loading device; personal computer. Since the investigated system operates in the mode of torque regulation then loading unit performs stabilization of angular velocity of mechanically connected electric machines and provides the function of torque measurement, developed by the investigated AM.

For comparative testing algorithm of frequency control of the torque [2], algorithms of vector control: without measurement of stator currents [3], robust [4], without measurement of angular velocity, algorithm, constructed on the basis of general theoretical solutions [5] have been selected.

At the first stage of testing experimental static characteristics of the investigated systems were measured To obtain the points of static characteristics by means of loading block, the velocity of shaft rotation of the investigated AM were set, after that excitation of AM with further operation of the preset torque in the investigated system was carried out. After the completion of transient processes measured value of AM torque was registered. The resulting static characteristics are shown in Fig. 1, where the preset torque M^* is presented by a dotted line and characteristics in case of frequency control – by solid lines. Using the algorithms of vector control [3] – [5], torque produced by AM equals the preset value, hence, static characteristics in the systems with vector control coincide with the lines of the preset torque. This proves the asymptotic property of torque and flow regulation, provided by the algorithms [3] – [5].

Static characteristics of the system in case of frequency control of the moment are of nonlinear form, torque, developed by the motor differs considerably from the set one, especially in the zone of low velocities. From the point of view of traction electric drive, the emerging mistakes of torque operation lead to deviation of the vehicle acceleration from the preset one, this can make negative impact on the conditions of road safety. What is more, as it is seen in [6], such form of characteristics leads to the impossibility of vehicle acceleration when moving upward driving uphill and braking to zero speed, when moving downward.

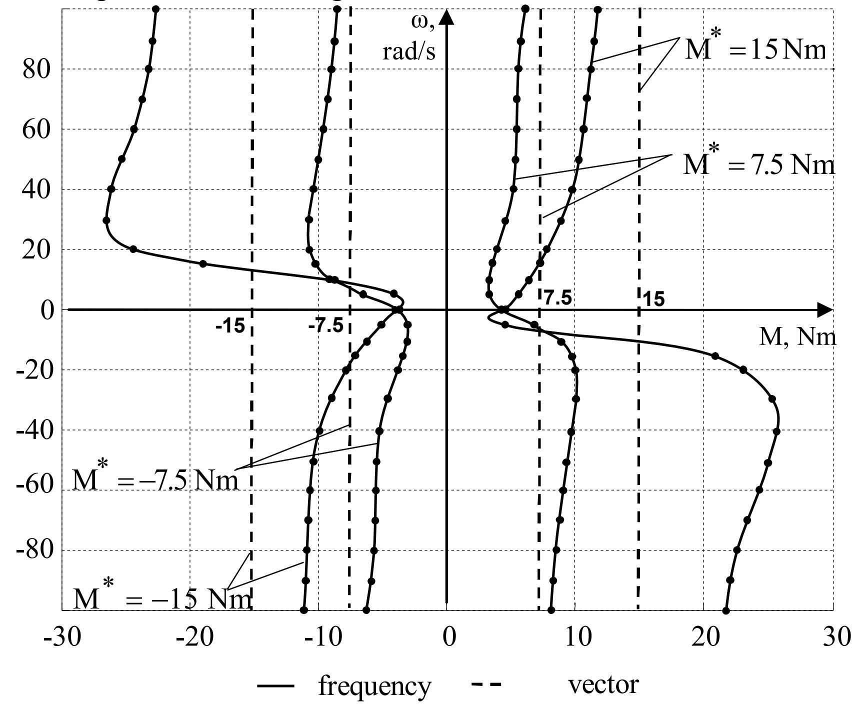

Fig. 1. Static characteristics

At the second stage, dynamic processes of torque operation are investigated. For this purpose, the following sequence of control operations is applied: loading unit, stabilizes angular velocity of AM at preset level; excitation of the investigated AM is performed; motor must perform the preset trajectory of the torque, attaining nominal value with limited first derivative, equal 150 Nm / s. The set trajectory of the torque is shown in Fig. 2.

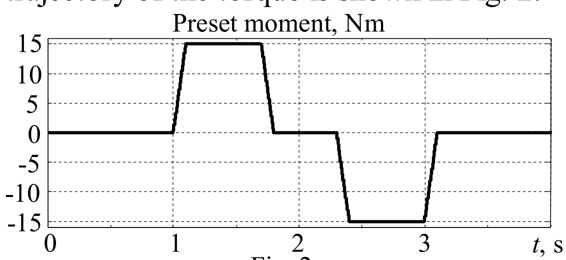

Fig. 2

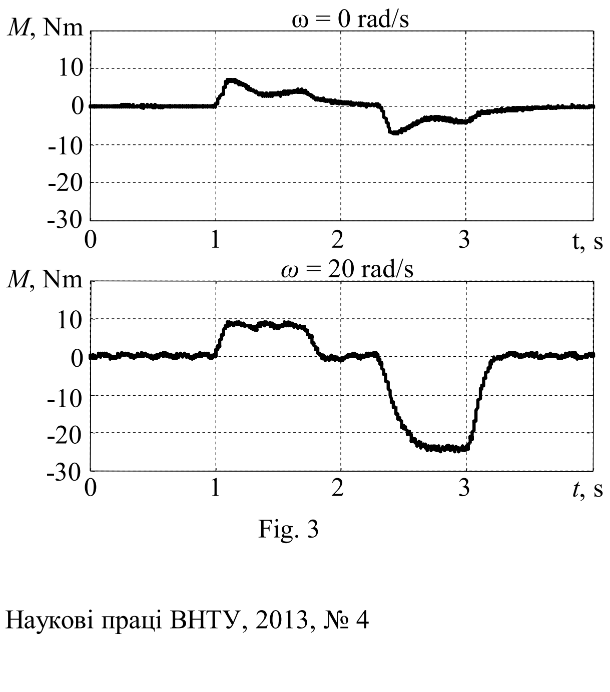

Fig. 3

Graphs of transient processes of torque operation in the systems of frequency control at different velocities are shown in Fig. 3, and in systems of vector control - in Fig. 4. From Fig. 3 it is seen that the processing of the trajectory of the torque in case of frequency control, takes place with numerous mistakes. In particular, when operating at low velocities vibration of the processes, decelerated growth and drop of motor torque, as well as intervals of torque generation at its zero setting. Dynamic behavior of torque frequency control system is improved when operating at average and high velocities, however, static errors remain considerable.

Systems of vector control demonstrate approximately similar dynamic characteristics while processing of the preset trajectories of the torque in the total range of velocities, where the study was performed. From the graphs of transient processes, shown in Fig. 4, it is seen that the shape of the responded

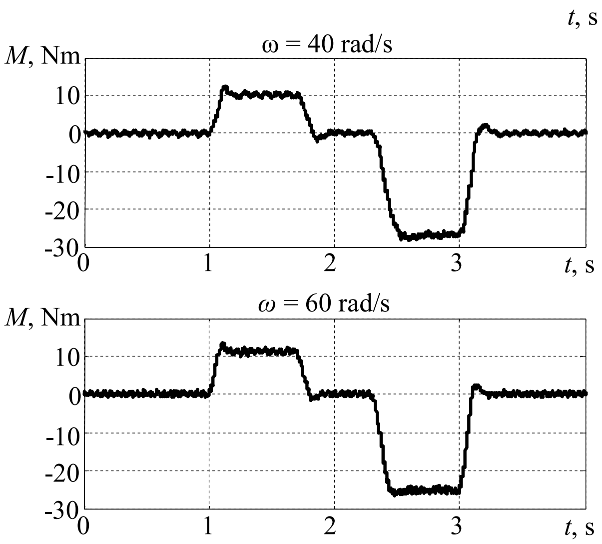

Fig. 3 (continue)

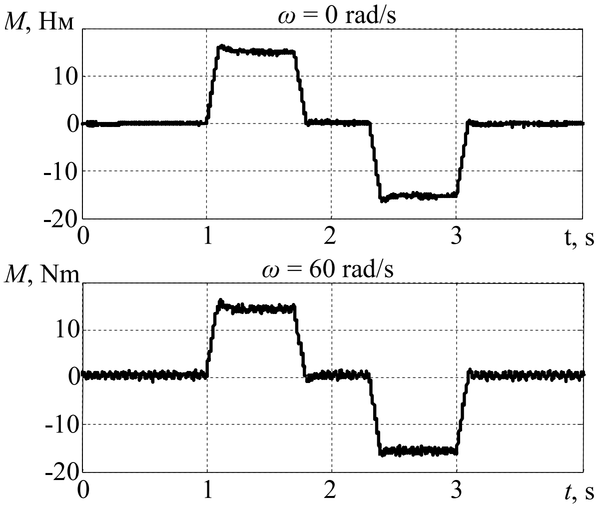

Fig. 4

torque, repeats with high accuracy the preset trajectory, shown in Fig 2 that experimentally proves properties of asymptotic processing of the torque in dynamic modes, which are provided by the use of vector control algorithms [3] - [5].

The given results of the study of static and dynamic characteristics of AM torque control systems experimentally confirm the results of [6], obtained on the basis of mathematical modeling.

Conclusions. The results of experimental testing of AM torque regulation systems, constructed applying frequency and vector control methods, are presented. It is shown that usage of frequency control of traction AM torque results in the possibility of emerging undesirable, from the point of view of road safety, modes. At the same time algorithms of vector control, including control without sensors, provide asymptotic operation of the preset trajectories of the torque, that enables to form the required dynamic characteristics of vehicles.

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