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SYSTEM OF ELECTROMECHANICAL ENERGY CONVERSION OF THE ELECTRIC DRIVE OF THE ROLLING STOCK WITH INERTIAL ENERGY ACCUMULATOR

СИСТЕМА ЕЛЕКТРОМЕХАНІЧНОГО ПЕРЕТВОРЕННЯ ЕНЕРГІЇ ЕЛЕКТРОПРИВОДУ РУХОМОГО СКЛАДУ З ІНЕРЦІЙНИМ НАКОПИЧУВАЧЕМ ЕНЕРГІЇ

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The functioning and principle of operation of mechanical inertial energy accumulators are considered. The diagram of the placement of the traction equipment on the electric rolling stock is given. As a system of electromechanical energy conversion, a direct current electric drive with a semiconductor switch and excitation from permanent magnets is adopted. Distribution of the flow of electrical energy to the drive and storage in the storage device occurs due to the parallel inclusion of the traction inverter and the reversing converter, which ensures two-way current flow.

Electricity consumption on railways is much higher than on other modes of transport [1, 2]. One of the promising means of saving electricity and improving its quality in railway transport is the use of electric energy storage devices, which are electrotechnical devices designed for the distribution of instantaneous power values between the generating source and the consumer [3, 4].

According to their energy indicators, mechanical inertial energy accumulators, which are a combination of a kinetic energy accumulator – a rotating flywheel and an electromechanical energy conversion system – have become the most widespread [5, 6]. Structurally, the flywheel and the electromechanical energy converter are united by means of a shaft into one unit.

An important advantage of inertial energy accumulators is that the circuit of the traction electric drive does not require the use of complex control and switching schemes [7]. As a system of electromechanical energy conversion, a direct current electric drive with a semiconductor switch and excitation from permanent magnets is adopted. A rotating inductor is an alternating pole magnetic system.

The layout of the traction equipment on the electric rolling stock using four wagons is shown in Fig. 1.

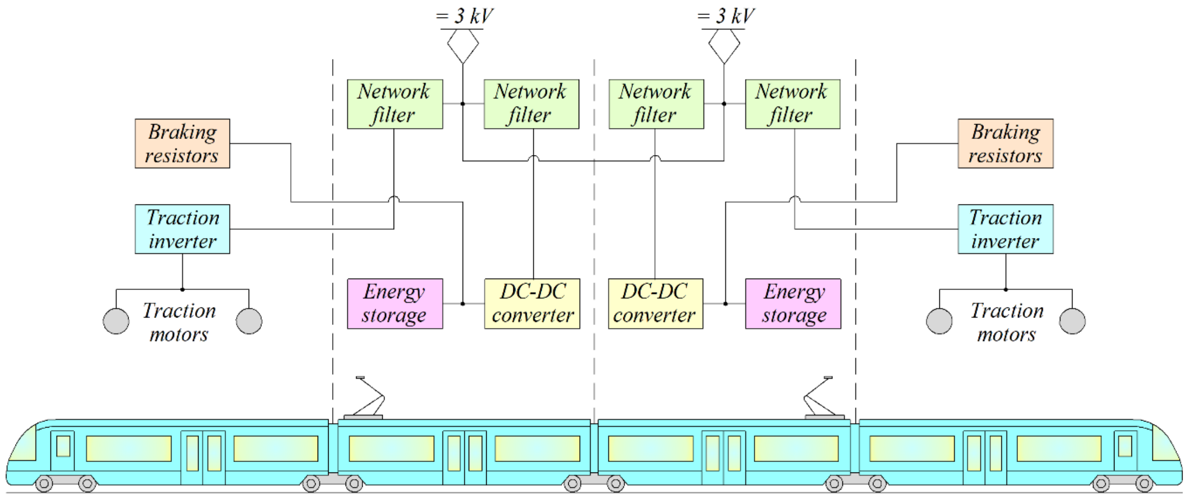

Fig. 1. Scheme of placement of traction equipment on an electric rolling stock

The difference of this scheme of the electric train is that in the system of its traction electric drive, an energy accumulator is provided, which in the braking mode should store kinetic energy, so that later, when the train accelerates, it can be released through the traction chain. To make the device compact, the electromechanical energy converter is placed inside the cylindrical rotor. The accumulator stores energy when the electromechanical energy conversion system operates in engine mode, while the rotor speed increases. A releases energy when the system switches to generator mode and the rotor speed decreases.

The inertial energy accumulator considered in the work provides for its operation during the operation of electric rolling stock in the cycle "braking – parking – acceleration". To do this, a DC-DC converter capable of providing a voltage difference across the traction motor and storage terminals in order to maintain the circuit's power current must be used in the traction drive system with the storage device.

The traction drive, consisting of two identical traction units, receives power through the protection equipment from one of the two current receivers. The traction unit contains two chains connected in parallel – traction and storage. Each of the converters of these circuits has a direct connection to the traction network through an input filter.

The traction chain includes a network filter, a traction converter and two traction motors connected in parallel. The network filter protects the electric drive from possible overvoltages in the traction network. The traction converter, which provides regulation of the torque and rotation frequency of asynchronous motors, is an autonomous voltage inverter. The storage circuit consists of a network filter, a DC-DC converter, braking resistors, and an energy store. Such a scheme of the electric drive makes it possible to use for traction the current coming both from the contact network and from the energy store. During regenerative braking, the braking energy can be returned to the contact network and simultaneously stored in the storage device (Fig. 2, 3).

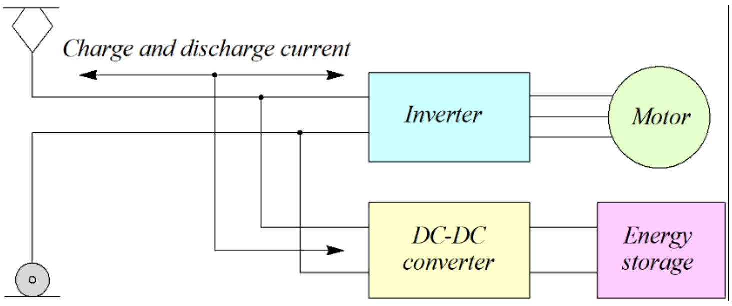

Fig. 2. Structural diagram of traction electric drive

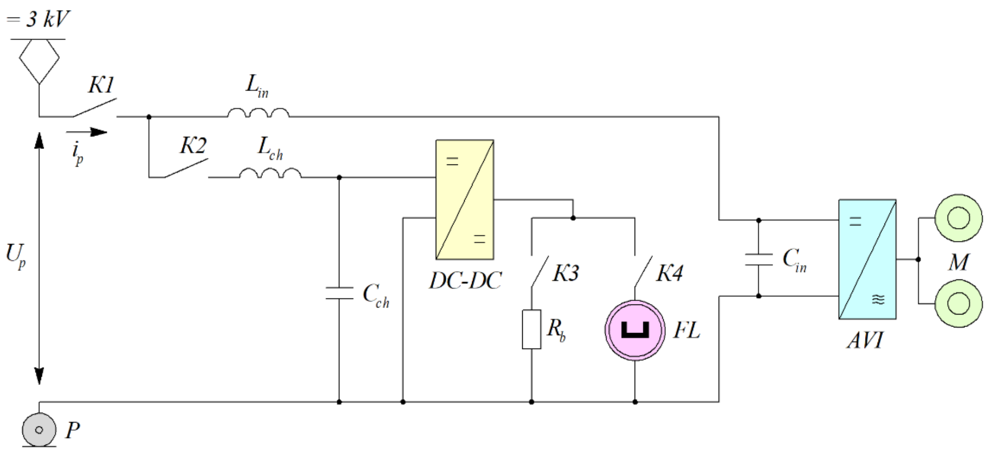

Fig. 3. Functional diagram of the traction unit:
DC-DC – step-up-step-down DC-DC converter; FL – inertial storage system; AVI – autonomous voltage inverter; M – asynchronous motors; K1...K4 – control switches; L_{in}, L_{ch}, C_{ch}, C_{in} – inductances and capacities of network filters; R_b – braking resistor; U_p, i_p – contact network voltage and current

Distribution of the flow of electrical energy to the drive and its storage occurs due to the parallel inclusion of the traction inverter and the reversing converter, which ensures two-way flow of current. It is possible to implement this with a control system that will exclude the supply of energy from the contact network to the storage device during recovery, and its outflow from the storage device to the contact network in traction mode.

The schematic diagram of the inclusion of the storage device in the traction drive of the electric rolling stock with a DC-DC converter is shown in Fig. 4.

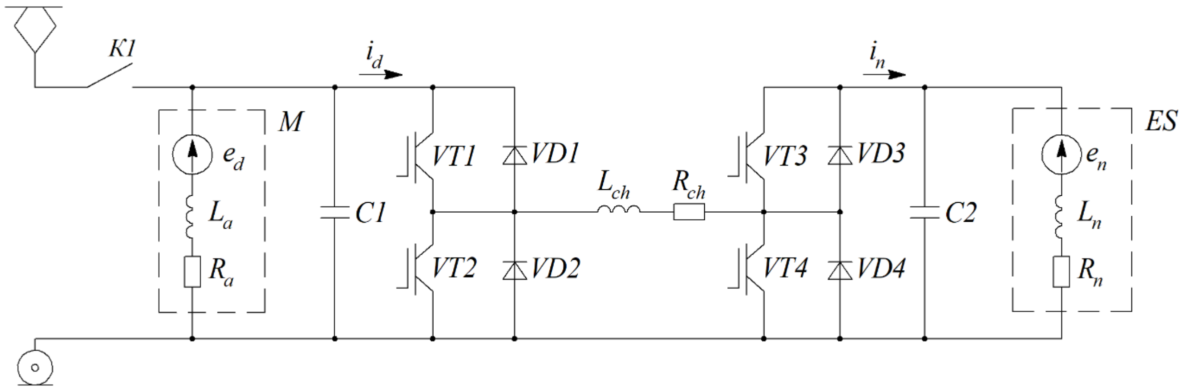

Fig. 4. Schematic diagram of connecting the storage device to the traction drive with a DC-DC converter: M – equivalent motor; ES – energy storage; VT1...VT4 – IGBT; VD1...VD4 – diodes; L_a, L_n, L_{ch} – inductances of motor, storage, DC-DC converter; R_a, R_n, R_{ch} – active resistances of motor, storage, DC-DC converter; e_d, e_n – electromotive forces of motor, storage; C1, C2 – capacitors

IGBTs *VT1...VT4* are used as controlled power switches performing high-frequency current switching. Reverse diodes *VD1...VD4* are necessary to form a circuit for current flow. The L_{ch} choke is used to store the energy obtained from the motor and then release it to the storage device with a certain switching algorithm. Capacitors *C1, C2* are used as filters.

Conclusions. The use of inertial energy accumulators on electric rolling stock makes it possible to save electricity in the power supply network. Also, an increase in the intensity of transportation is possible, which will contribute to a greater degree of competition with motor vehicles.

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