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ASYMMETRIES AND CONTROLS THE PARAMETERS OF THE SYMMETRICAL DEVICES IN EXTENDED ELECTRIC NETWORKS WITH TRACTION THE LOAD

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Annotation: The electrified railway system consists of two parts: the external part of the power supply system, which includes all devices from the power plant to the power lines supplying energy to traction substations; the traction part of the power supply system, which consists of traction substations and traction network. The traction network consists of a contact network, a rail track, supply and suction lines, as well as other wires and devices connected along the length of the line to the contact suspension directly or through special autotransformers. The device of a traction substation depends on the electric traction system used on the railway, i.e. it is determined by the type of current and voltage used in the contact network, as well as the voltage and current system of the energy source of the primary part of the power supply circuit.

Keywords: power systems, voltage asymmetry, magnitude

The most widely used power supply circuits are for three electric traction systems: direct current, single-phase current of industrial frequency and single-phase current of reduced frequency.

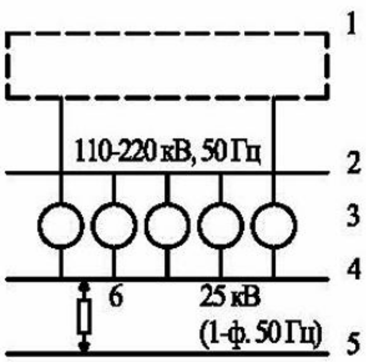

Figure 1.1 - Single-phase current system with an industrial frequency of 50 Hz, (1 - power system; 2 - power transmission line; 3 - traction transformer substations; 4 - contact network; 5 - rails; 6 - electric locomotive) The main advantage of this system in comparison with a DC power supply system is the possibility of using a higher voltage in the contact network,

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followed by lowering it on the locomotive. In Russia, a voltage of 25 kV is accepted. In this case, traction substations are simple transformer ones, and the cross-section of the contact networks is significantly reduced even with significant distances between substations (up to 50-60 km). Electric rolling stock with DC motors and a converter unit on the locomotive has become the most widespread. Transformers in such installations make it possible to regulate the voltage on motors under load. The industrial frequency system makes it possible to power a single-phase network from a three-phase one through a transformer. However, in the case of connecting a single-phase traction load from a three-phase network, there is an uneven loading of the phases of the primary power supply system. An unbalanced load negatively affects the operation of the elements of the primary network (transformers, generators, lines, relay protection). When the external power supply network is powered by powerful power systems, the traction load is a small fraction of the total system load. However, it leads to significant voltage asymmetry on the tires of traction substations and in the adjacent network, which has a negative impact on the operation of three-phase consumers connected to these substations. The disadvantages of this system can also include the influence of the traction network on low-current lines.

On single-phase alternating current railways, the contact network is usually connected from a three-phase power line via transformers. The simplest connection scheme is via a single-phase transformer, shown in Figure 1.2. In this case, on the entire line to the right and left of the substation, the voltage of the contact network is in phase with the voltage Uab in the external network. The contact network is partitioned, which makes it possible to disconnect only half of the supplied line in case of damage. The disadvantage of the circuit is that the third phase of the transmission line is not used and remains unloaded.

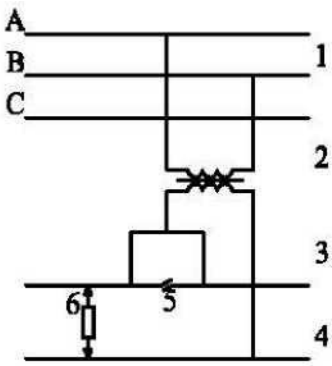

Figure 1.2 - Power supply scheme for a single-phase alternating current contact network from a single-phase transformer (1 - three-phase power line; 2 - transformer; 3 - contact network; 4 - rails; 5 - sectioning device; 6 - electric locomotive) A more uniform loading of the phases of the external power supply network can be achieved by connecting traction substations alternately from different phases of the supply line. In this case, the sections of the contact network to the left and right of the substation are connected to different phases of the supply line and have voltages that differ in phase. In the power supply networks of Russian railways, a circuit for connecting a contact network from three-phase transformers with a U/D

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connection scheme is common. The use of three-phase transformers makes it possible to connect three-phase (non-traction) consumers from a traction substation (Figure 1.3).

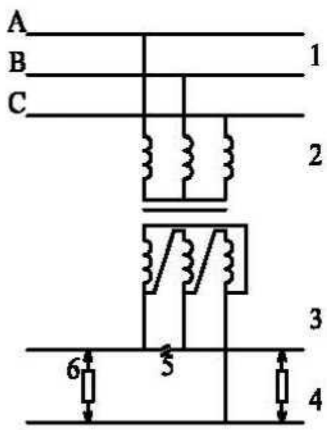

Figure 1.3 - AC contact network connection diagram using a three-phase transformer, with a Y/D connection diagram (1 - three-phase line; 2 - three-phase transformer; 3 - contact network; 4 - rails; 5 - partitioning device; 6 - electric locomotive) The secondary winding of the transformers is connected in a triangle, as shown in Figure 1.3. The connection diagram of the primary winding is a star, hence the voltage in the contact network between the contact wire and the Uac rails (on the left in Figure 1.3) and between the rails and the Ucb contact wire (in Figure 1.3, on the right) correspond in phase with the voltages of the primary side ia and Uc. The circuit in Figure 1.3 is a three-phase two-phase. When using this scheme, the three-phase system is unevenly loaded. One of the most common schemes for external power supply to railways in our country is the scheme for connecting traction substations from a 220 - 110 kV transmission line running along the railway. In order to reduce the load asymmetry on the busbars of the power supply and in the supply line and the voltage asymmetry in the network, the most loaded phases of the traction transformers are alternately connected to one or the other phases of the supply network. The order of alternation is determined depending on the connection scheme of transformer windings at substations, on the external power supply scheme, on the length of a given railway section, as well as on the number and actual location of traction substations relative to power sources.

It is known that with uneven load in a three-phase electrical system, the voltage asymmetry is largely determined by the voltage drop in the transmission lines. The voltage drop depends on the magnitude of the load and the location of the substations. Thus, it is clear that with any connection of traction substations to a three-phase supply line, it is not possible to obtain equal voltage losses in all three phases, due to the location of the unbalanced load at different distances from the power sources. This situation is complicated by the widespread scheme of power supply to traction substations from an extended double-chain line. Traction substations are connected alternately to both circuits of the power transmission line, which increases the load asymmetry on each circuit of the supply line, and accordingly leads to voltage asymmetry at the network's nodal substations.

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