



Voltage balancing in the system of power supply of high-speed rail transport

Juraeva Kamila Komilovna¹
Rustemova Aynura Rustemovna²

^{1,2}Tashkent Institute of Railway Engineers

ABSTRACT

The article deals with the issues of voltage balancing in power supply systems for high-speed electric transport. Considered the possibility of using balancing devices for traction networks.

ARTICLE INFO

Article history:

Received 02 Mart 2020

Received in revised form 25 April 2020

Accepted 22 July 2020

[Click here and insert your abstract text.](#)

© 2020 Hosting by Research Parks. All rights reserved.

Keywords:

high-speed, transport, voltage balancing is performed, resistances, transmission lines, the conditions of technology

Introduction

In the Republic of Uzbekistan, the movement of high-speed electric transport is carried out. The process of power supply of devices and elements has the features of the operation of electrical equipment, which in such conditions increases the requirements for traction networks. An AC traction substation has, as a rule, two supply arms. The voltage of one or another phase of the supply system is applied to each shoulder. Thus, each traction substation connected to a three-phase network supplies only two single-phase loads. Therefore, the loads created by electric traction in a three-phase electrical network are not symmetrical, i.e. different currents flow in its individual phases.

Different currents in the phases of power transmission lines with their identical resistances lead to different losses and voltage levels in them, i.e. to the asymmetry of the voltage supplied to the three-phase receivers of electrical energy. To reduce the influence of asymmetry, voltage balancing is performed, while special additional balancing devices are used only in cases where the following measures are insufficient:

- connection of unbalanced loads in network sections with the greatest possible short-circuit power (short circuit);
- allocation of asymmetrical loads of significant power to separate transformers;
- uniform distribution of single-phase loads across all phases.

Phase redistribution of loads does not always allow ensuring the symmetry of voltages within acceptable limits. This is due to the fact that a number of electrical installations, according to the conditions of technology and operation, are not constantly in operation.

In the presence of asymmetry (coefficient of asymmetry K_{2U} more than 2%) and when other measures are exhausted, a decision is made to balance the load with additional devices. The balun solves two problems at once:

- balancing loads;

- reactive power compensation.

The power of the capacitive element of the balancing device is selected $Q_{C.Y}$ from the conditions of full compensation Q_H of the reactive power of the load:

$$Q_{C.Y} = Q_H \quad (1)$$

Balancing the system of line voltages of a three-phase network is reduced to compensating the negative sequence current consumed by single-phase loads and the negative sequence voltage caused by it.

Balancing devices are manufactured controlled and uncontrolled depending on the nature of the load curve. Currently, a large number of balun circuits have been developed with electrical and electromagnetic connections between elements.

For balancing single-phase receivers of electrical energy with an almost constant load curve and a power factor close to 1, the Steinmetz scheme is used. The required power of the capacitor C_ϕ bank and the choke is determined from the L condition

$$Q_C = Q_L = P_0 / \sqrt{3}$$

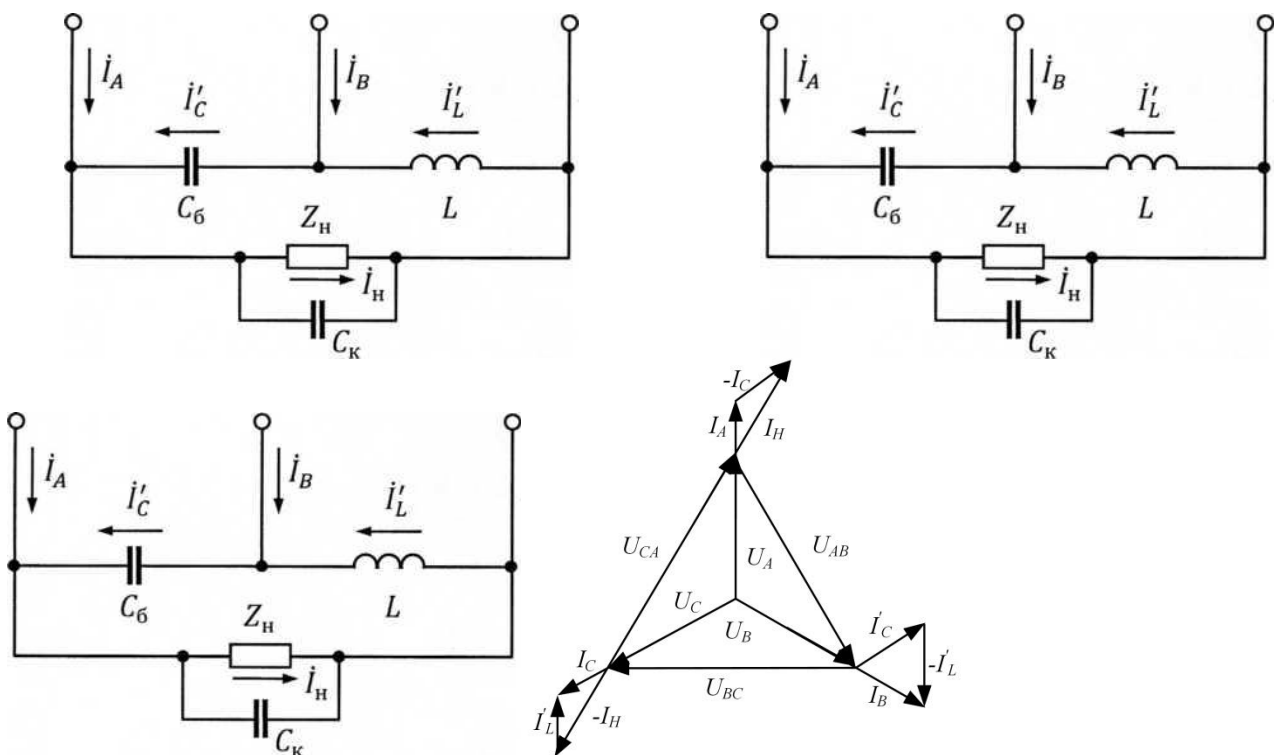


Figure: 1. Balancing scheme Fig. 2. Vector diagram of currents single-phase Steinmetz load and voltages for the Steinmetz circuit

Negative sequence current compensation is carried out using a capacitor bank and a choke.

It should be borne in mind that this scheme is most effective when balancing a purely resistive load.

Controlled balancing devices, as well as uncontrolled ones, in most cases are made according to the Steinmetz scheme. They differ from uncontrolled ones in that the capacities of the capacitor bank and the choke are regulated by disconnecting part of the sections of parallel connected capacitors and switching the choke taps or disconnecting individual chokes .

For balancing a single-phase inductive load, a circuit with a choke-divider is used (Fig. 3). The balun, made according to the scheme with a choke-divider, can be made controlled and uncontrolled, depending on specific conditions.

Balancing of two - and three-phase unbalanced loads with low power factor can be accomplished using a three-phase unbalanced capacitor bank (Fig. 4). In general, the capacitors' powers in each phase can be unequal:

$$Q_{C_{AB}} \neq Q_{C_{BC}} \neq Q_{C_{CA}}$$

Three-phase symmetrical capacitor banks only compensate for the reactive component of the current and do not affect the active component.

When using baluns, it should be borne in mind that its installation entails additional investment and operating costs. Therefore, it can sometimes be economically justified to use a star-zigzag-zero transformer without a balun instead of a star-star-zero transform and an additional balun.

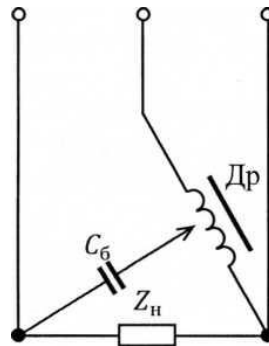


Figure: 3. Balancing circuit with choke - divider

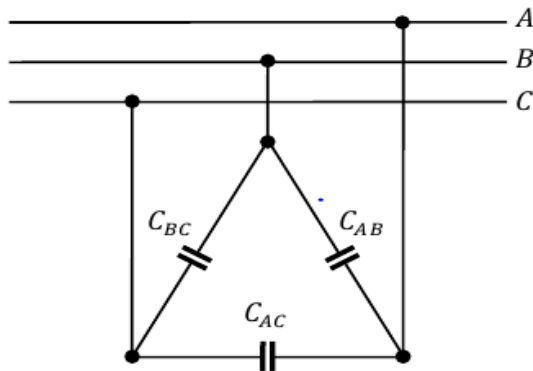


Figure: 4. Scheme of balancing an unbalanced three-phase load using an unbalanced capacitor bank

In addition, instead of balancing devices with magnetic connections between the elements, it is possible to use a special transformer with phase regulation. The ratios of the turns of the transformers are chosen so that the voltage unbalance in the supply network (U_{AB}, U_{CA}, U_{BC}) does not exceed the permissible values.

Balancing devices of the transformer type, as a rule, are individual and unregulated [3].

With a sharply variable load with varying phase asymmetry and, in addition, generating higher harmonics, balancing by the methods described above fails.

An example of such loads is AC rail transport.

To improve the quality of electricity and at the same time to compensate for reactive power in the power supply of high-speed transport, you can use multifunctional filter balancing devices (FSU). The filter balancing device is built on the basis of static thyristor compensators, thyristor switches, line reactors and variable capacitor banks. FSUs have sufficient speed, are protected from higher harmonics and do not contain rotating parts. These circumstances make FSU more preferable than

high-speed synchronous compensators and unregulated capacitor banks.

REFERENCES

- Borodulin BM Balancing currents and voltages at operating AC traction substations // Vestnik / Vseros. scientific research Institute of Railways transport. - 2003. - No. 2. - P. 17-24.
- 2. K.Kh. Turdibekov, I.B. Kurbanov. Modeling asymmetric modes in the power supply system of railways. // Republic of zhanubid transport-yʻil kompleksini rivozhlantirish istiqbollari. Republic of ilmiy-technician Anjuman Termiz-2017, 336-338s.