# Centralized normalization of harmonic voltages in the supply network for traction substations

L.I.Kovernikova

The Siberia Branch of the Russian Academy of Sciences
Energy Systems Institute
130, Lermontov Str., 664033 Irkutsk (Russia)
Phone:+7 3952 426495, fax: +7 3952 426796, e-mail: **kovernikova@isem.sei.irk.ru**

The paper solves the problem of centralized reduction of harmonic voltages (the indices $K_{U(n)}$) at the nodes connecting traction substations on railway to the supply HV network via the passive C-type filters.

1. A section (above 900 km long) of the railway in East Siberia with 23 traction substations is studied. The traction substations located at a distance of 40-60 km are supplied with power from the 110-220 kV network. The 40 MVA transformers installed at the traction substations are supplied with power from the HV network and transmit it to the 25 kV traction network and the 10-35 kV network of remaining consumers. DC engines of electric locomotives are nonlinear facilities consuming nonsinusoidal current. The engines receive power through the single-phase two-pulse rectification circuits.

2. Analysis of the measured currents of traction load reveals predominance of the 3rd, 5th, 7th harmonic components in them. The 3rd harmonic current accounts for 25-30%, the 5th harmonic one – approximately 10%, the 7th harmonic one – about 8%. These currents distort a voltage curve shape at the connection nodes of traction substations. Analysis of the indices $K_{U(n)}$ for these harmonics measured at the connection nodes of traction substations shows that their values are much higher than the norms established by the Russian State Standard 13109-97. The calculated indices $K_{U(n)}$ for the 3rd, 5th, 7th harmonics in the studied network at 12 traction substations exceed standards.

3. Centralized normalization of harmonic voltages at the connection nodes of traction substations with the help of C-type filters is suggested to decrease the impact of traction load on voltage at the supply network nodes. The filters are planned to be installed on the HV buses only at several traction substations of the considered section. But their parameters and installation points should be chosen so as to decrease the values of $K_{U(n)}$ at all the nodes of the section.

4. The parameters of the C-type filter (Fig.1) are calculated taking into account the two constraints:

1) at fundamental frequency the filter is a reactive power source, it generates reactive power $Q_{C1}$ to the network,
2) for the tuned ***n***-th harmonic the filter provides the desired value of $K_{U(n)}$ at the node, here reactive resistance of filter equals zero and active resistance equals $R_d$.

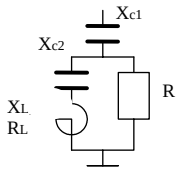


Fig.1. Schematic diagram of the filter

The value of $R_d$ is determined based on the calculation of the network parameters and operating conditions at the ***n***-th harmonic.

5. The most challenging task is to choose the traction substations for the filters to be installed. The algorithm for choosing the network nodes for installation of filters is presented. The choice of nodes for the filters to be placed starts for the harmonic of the least number. Preference is given to the nodes at which:

1) filters extend their action to a larger number of neighboring nodes,
2) filters decrease harmonic voltage by a large value,
3) filters have the least active power losses.

6. The example of filters chosen for the 3rd, 5th and 7th harmonics is presented for the considered network. These three filters turned out to be enough to install at one of the substations of the considered section in order to decrease the 3rd, 5th and 7th harmonic voltages in accordance with the requirements of the Russian State Standard.

7. The efficiency of chosen filters is estimated for various loads and operating conditions of the network.

8. Active power losses in the filters are analyzed.