Mitigation of urban substation magnetic field by active loop

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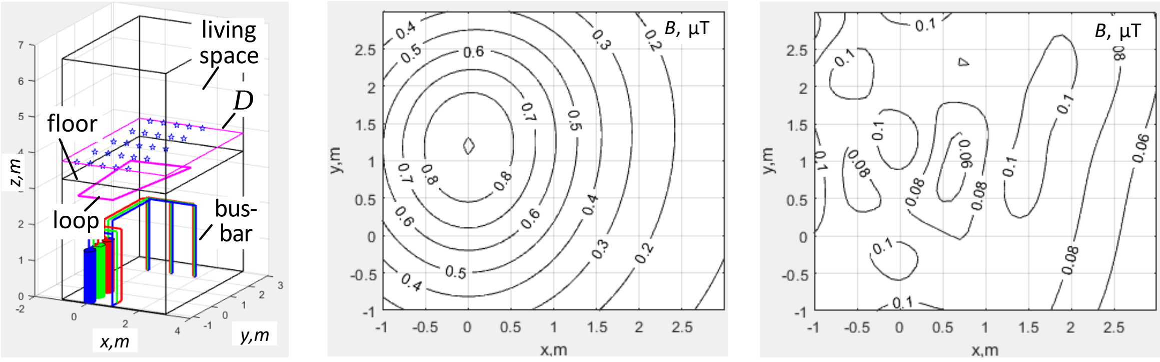
1. Introduction

Urban transformer substations can be found in special rooms inside civil structures and residential buildings. These substations create a magnetic field in the surrounding space, as well in the living space. So some measures to mitigate the urban substation magnetic field in neighboring living space are to be taken. One of the ways is to use active shielding methods that provide the highest efficiency of magnetic field mitigation [1]. For this the active loops powered by a regulated current source are installed. The idea of the active shielding is to use these loops to create the magnetic field opposite to the urban substation magnetic field. The main problem related to the complex form of bus-bars in the substation. This leads to the inhomogeneity of the substation magnetic field. So the highest efficiency of the magnetic field mitigation is achieved only at some points, but not in all living space. To increase the shielding efficiency, it is proposed in [1] to aspire to the homogeneity of the mitigated magnetic field in the living space. This could be achieved by choosing optimal geometry of the active loop, its arrangement relative to the source of the magnetic field and the living space, and the current in the loop. The technique for optimization of active loops for magnetic field mitigation of urban substations is developed by the authors in [2]. In this paper, a numerical simulation is carried out using the MATLAB software package and the results of an experimental research conducted with a substation model are represented.

2. Computer simulation

Here we consider a substation with a rated power of 100 kVA and 10/0.4 kV transformer (Fig. 1a). The living room is located on top of the substation. To guarantee the magnetic field mitigation in the entire living room, it is enough to mitigate it within the control plane D distant from the floor room by 0.5 m [2]. Fig. 1b shows the distribution of the substation magnetic field when the current in low-voltage bus-bars is 100 A. The maximum value of RMS of the magnetic flux density in plane D is about 0.8÷0.9 µT. We use the optimization technique from [2] to determine the parameters of the active loop. So the active loop having 5.2 ampere-turns is located 1.05 m away from the substation bus-bar. Fig. 1c shows the mitigated magnetic field distribution. The magnetic flux density is reduced to 0.1 µT and lower. And the shielding efficiency is 8 units and more.



a b c

Figure 1. Computer simulation results

3. Experimental research

The substation model shown in Fig. 2a is made in a one-to-one scale. Fig. 2b shows the measured magnetic field of the substation in the plane D. Here the current in low-voltage bus-bars of the substation is 53 A. And the maximum value of RMS of the magnetic flux density is 0.64 μT. We use the active loop having 10 turns. Its total resistance is 4 Ohm. The current in the active loop is 0.24 A. Energy consumption is less than 0.01 kW.

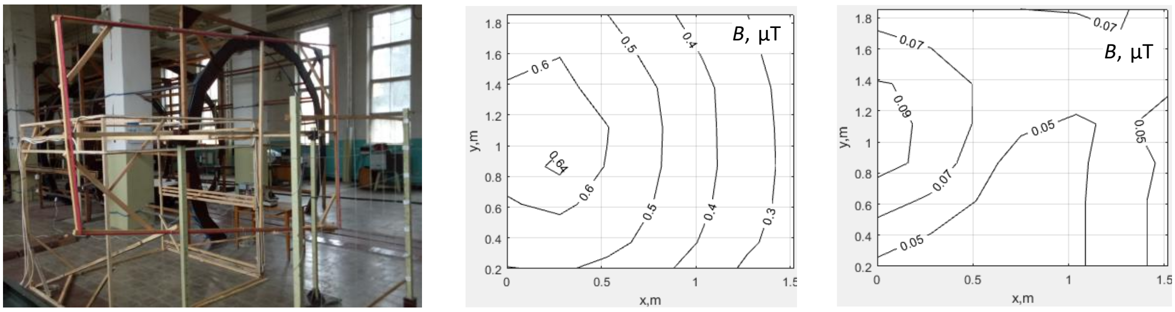


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Figure 2. Results of experimental researches

Fig. 2c shows that the usage of the active loop mitigates the magnetic field to 0.09 μT. The mitigated magnetic field is not uniform, but its fluctuations are comparably low. Wherein, the shielding efficiency is more than 7 units.

References

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