SHIELDING OF THE ELECTROMAGNETIC FIELD GENERATED BY HV UNDERGROUND CABLE LINES.

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ABSTRACT

The paper illustrates the main techniques adopted to shield the electromagnetic field (EMF) of HV insulated lines. The consolidated technology of passive loops and ferromagnetic raceways are here described, with details on performances and installation procedures. A shielding technical package is presented, capable of reducing the magnetic field of the power cables laying either in the trench or in the joint bays, with perfect continuity. It is essential that the designer coordinates the shielding of the trench next to the joint bay to avoid leakages or longitudinal propagation of the magnetic field. Thermal results are also presented.

KEYWORDS

EMF - Mitigation - Shielding Factor - Passive Loops - Raceway - Ferromagnetic Box – Joint bays.

INTRODUCTION

Various are the techniques implemented to mitigate the magnetic field, with different Shielding Factor (SF) and applications. The method, generally used to slightly reduce the electromagnetic field, is to adjust the laying parameters such as interaxial distance between the phases, geometry or moving the circuit further. If a greater reduction of the EMF is requested, a common solution is the adoption of special shielding apparatuses external to the cables such as insulated conductors grids or ferromagnetic enclosures.

The installation and the thermal design strategies linked to the induced losses are also important, and a careful analysis is necessary in order to properly balance the shielding efficiency to achieve the required field mitigation with a negligible impact on the rating.

In critical situations, such as transition points, the magnetic field cannot be predicted only with 2D approximation and specific shielding must be designed locally.

SHIELDING THE FIELD OF A HV CIRCUIT

In urban areas, where most of the HV insulated cables are shielded, there are variations in the laying configuration or depth and every some hundreds of meters there is a joint bay where the cables have a larger interaxial separation.

Also the distances of the houses vary along the cable route, so that the HV system designer has to consider all these different aspects to finally determine the best technology to shield the magnetic field and verify that it is not exceeded according to the restrictions imposed by the law.

The Shielding Factor of a given mitigation technique is considered here as the ratio between the magnetic field modulus of the bare circuit, divided by the EMF resulting with the adoption of the mitigation measures, computed or measured at 1 meter above ground, on the axis of the circuit [1].

The following Figure 1 shows the magnetic shielding of a 400 kV circuit, in which the peak level is progressively reduced from 30 µT to less than 2 µT, with the adoption of more effective mitigation devices.

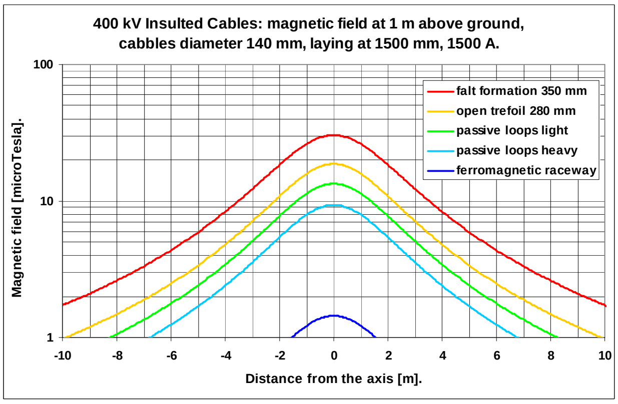

Figure 1. Magnetic field according to different shielding solutions.

It can be noted that the corresponding right of way, for example evaluated at 3 µT, is annulled, from an initial value of more than 7 m on each side [3]. The cables are firstly arranged in flat formation, with an interaxis of 350 mm to maximize the rating and simplify the laying operations, giving the EMF reported in the uppermost line of Figure1. A first EMF reduction is obtained moving the cables into open trefoil configuration, with a 280 mm interaxis that keeps the same rating for the circuit (second line of the same Figure). Further magnetic reduction can be obtained with passive loops: number, section, and position of the cables contribute to increase the SF, with negligible thermal heating. The best result (bottom line) is obtained with a ferromagnetic raceway; a reduced laying depth or other thermal precaution can be necessary to maintain the local rating of the circuit.

CABLES SHIELDED WITH PASSIVE LOOPS

The design of the passive loops is not difficult: the position of the cables can be easily varied and the total number increased by simply adding more cables.

Low voltage cables are usually installed, due to the very low voltage induced along the cables: they are arranged in the same trench of the HV cables, either directly buried or in dedicated plastic pipes. Section and the position of the passive cables are optimized to maximize the SF [2].

Shielding of cables laid in flat formation is easier because optimum disposition of passive cables is also in flat formation; for a trefoil arrangement, the passive cables