INVESTIGATIONS INTO THE DESIGN OF EMF MITIGATION TECHNIQUES

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ABSTRACT

Several EMF mitigation techniques have been assessed (efficiency, technical and economical parameters), depending on the situation faced.

Conductor management and geometry are the first steps to minimise the magnetic field generation without any mitigation device. Ferromagnetic materials are interesting in corbelling areas: common steel turns out to be a good compromise between cost and mitigation performances. Passive loops can be interesting in a joint bay area because of the compromise between the required efficiency, ease of installation and cost.

The authors discuss their experience within a TSO company, focusing on these mitigation techniques design.

KEYWORDS

AC underground links, Cable laying methods, Magnetic Field, Shielding Factor, steel pipe, ferromagnetic, conductor management, passive loop, Finite Element Method

INTRODUCTION

Although not binding with regard to the European legislation, the value of 100 µT is widely accepted as a reference value for public exposure to ELF magnetic fields. In very localised points, specific configurations (corbelling way on a bridge for example) make the cables quite reachable: the field can exceed 100 µT at the immediate vicinity of the circuit, and a mitigation technique with a specific device may be required.

In addition, a pro-active behaviour may consist in lowering the field value in uneven local points as joint bays to the value measured above the regular cable route where such a decision is justified by a tight societal situation.

Each mitigation technique has to be characterised and designed considering several technical and economical criteria: efficiency (evaluated by the Shielding Factor), ease of installation, losses, impact on investment cost and operation cost, maintenance and life duration.

Based on analytical calculations (Biot-Savart law) and numeric simulations (Finite Elements Method), the performances of different mitigation techniques with an appropriate design being a technical and economical compromise are presented.

GEOMETRICAL APPROACH AND CONDUCTOR MANAGEMENT

Influence of laying geometry

In this section, we compare magnetic field values generated by a single three-phase circuit whose cables are laid in ducts. The common geometry used within RTE is an equilateral triangle. The installation is convenient, especially when ducts are touching (cables in buried HDPE ducts in rural areas). This regular trefoil leads to the most favourable EMF behaviour and will be our reference.

- All the concrete banks have the same trench depth, meaning that lower cables or ducts of all configurations are at the same distance L_{low} from the ground surface.
- Ducts (therefore cables) are spaced out with the same distance *s* between axes.
- Calculations are performed above the cable route. The maximum magnetic field value is plotted on the following chart.

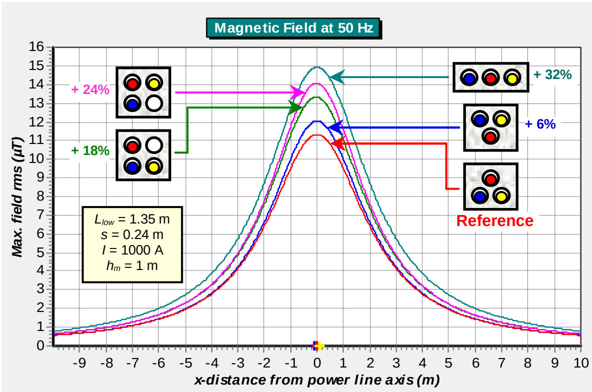

Fig. 1.1: Magnetic Field values for several geometries

The highest value is much lower than the 100 µT recommended value.

- The regular trefoil formation is recommended for its behaviour with respect to a reduced magnetic field.
- The differences between configurations can be explained by the best mutual field compensation of axis-symmetrical configurations, and by the distance between each cable (field source) and the position of field measurement / calculation.
- The ratio of field values between flat and trefoil formations with the same distance between conductors is $\sqrt{2} \approx 1.41$ when the circuit centres are of same depth.

The magnetic field is linearly proportional to the axial separation of conductors. Compaction is favourable to a reduced magnetic field, but increases mutual heating of cables. The minimum distance is achieved for touching cables, but this extreme configuration implies a lower current rating and higher losses.

Conductor management of multiple circuits

Conductor management is an efficient way to reduce electromagnetic fields directly at the source, acting on the geometry of the cables that generate the resulting field. In the case of multiple circuits, the phase sequence becomes relevant and must be taken into account at the early step of the system design.