MAGNETIC MITIGATION OF HV JUNCTION ZONE

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ABSTRACT

In this paper a new concept of passive loop technique called "High Magnetic Coupling Passive Loop" (HMCPL) is presented. The proposed shielding technique is characterized by high performances and takes all the advantages of passive and active shields. In the present paper the proposed shielding is deeply analysed.

Thanks to the experience obtained installing 10 HMCPL systems on high voltage power lines realized from the most important cable producers and installers in the world all the technical improvements that can be adopted during the installation will be described and discussed.

Finally, the actual performances one HMCPL system will be detailed showing: measurement on magnetic flux density without and with the shield and thermal analysis.

KEYWORDS

Mitigation; shield; magnetic field; passive loop; HMCPL; shielding factor; power line.

INTRODUCTION

The "High Magnetic Coupling Passive Loop" (HMCPL) allows the mitigation of the field produced by a group of conductors (i.e. the source) through another system of cables strongly coupled with the source, Figure 1, [1].

The classical passive loop principle is based on the Faraday's induction law, hence the alternating magnetic flux due to the source creates an induced current in the loop in such a way that the magnetic field produced attempts to compensate the original field (Lenz's Law) [2]. In the standard passive loop the magnetic coupling is done in air (low coupling) while in HMCPL the magnetic cores are introduced in order to reach a high magnetic coupling between source and shield. With these cores it is possible to induce in the shield a current (I_{sh}) with opposite phase with respect to the source one (I_s) while usually, between source and induced current, in a typical passive loop there are 90° [2]. The magnetic cores have to be carefully designed in order to avoid saturation effect when the power line brings his rated current but this point is not the issue of this paper.

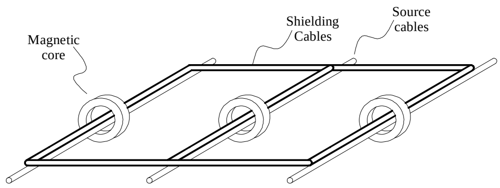

Figure 1 - layout of the HMCPL

The working principle of the HMCPL is very simple. First of all the magnetic core behaves as a transformer therefore it can be simply represented with the circuital model of Figure 2. Looking at this figure it is clear that the HMCPL works as a secondary circuit of a three-phase transformer.

The HMCPL is few meters long, usually from 10 to 20 m depending on the application. Therefore its total impedance is negligible if compared with the one of the power line. The conclusion is that the introduction of the HMCPL can not modify the power line absorption which is imposed by the current load condition. In the end, each phase of the power line could be modeled by means of a current generator which represents the load profile as shown in Figure 2.

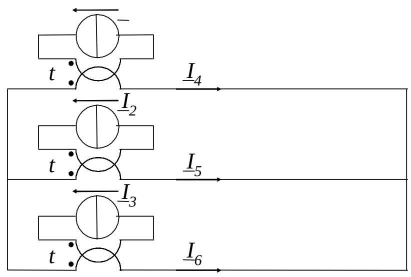

Figure 2 - HMCPL: the magnetic core represented by means of the transformer model and the power line could be represented by a current generator

Finally, the relation by the source and shielding current is completely given by the model of the transformer (which represents the ``high coupling"), therefore:

$$\begin{cases} \underline{I}_4 \approx -\underline{I}_1/t \\ \underline{I}_5 \approx -\underline{I}_2/t \\ \underline{I}_6 \approx -\underline{I}_3/t \end{cases} \tag{1}$$

The approximation symbol in (1) is used in order to take into account the losses inside the ferromagnetic core and the magnetization current. By neglecting for a while these non ideality factors, the result is clear: in a HMCPL system with unitary coupling (t=1) the shielding current is equal in amplitude and opposite in phase w.r.t. the source one.

Finally, a consistent improvement can be obtained by means of the phase splitting technique. It consists in subdividing the phase shielding conductor in more than one subconductors that can be displaced around the source conductor.

If *N* in the number of subdivision, each sub conductor will carry the current I_{sh}/N.

From now on all the configurations described will be related to the one represented in Figure 3 where the unitary coupling is used and 4 shielding cables are installed for each source cable.