A REDUCTION METHOD OF THE MAGNETIC HUMAN EXPOSURE IN PROXIMITY OF HIGH-VOLTAGE OVERHEAD POWER LINES

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Problems concerning human exposure to ELF magnetic fields have been debated in recent years. The mechanisms of biological effects in humans from electric and magnetic field exposure have been studied, recognized and standardized [1, 2]. These human interaction mechanisms fall within the category of short-term effects. The international Standards define exposure limits based on these short-term effects. Moreover, also the possible links between ELF magnetic exposure and certain forms of cancer (long-term effects) have attracted the attention of researchers of many countries. Unfortunately, the results obtained are controversial. The epidemiological associations between magnetic long-term exposure and serious diseases are neither sufficient nor confirmed in order to redefine the international Standards exposure limits.

UE countries have accepted the limits suggested in [2], which are considered good enough to avoid the short-term effects. But the uncertainties about the potential effects of long-term exposure have driven some countries (such as Italy) to keep a cautionary position by introducing lower exposure limits. The recent Italian laws [3] establish two new exposure limits (beside the short-term limits) called “attention value” and “quality target”. The first one is the field value that must not be exceeded in those environments where people stay more than 4 hours: this value is set equal to 10 μT. The second one is the field value to be considered in the design of new High Voltage transmission lines in order to minimize the exposure to magnetic field progressively: this value is set equal to 3 μT.

In order to reduce the magnetic emission of the transmission lines that are not compliant with the new limits a reconfiguration of the line conductors has been suggested [4]. This criterion is based on the source alteration. However the magnetic emission reduction obtainable by this change of configuration occurs only in the transmission line right-of-way. On the contrary, at greater lateral distances, that is in those environments to be protected, (therefore outside the transmission line right-of-way) the magnetic induction profile holds quite unchanged with respect to the previous line configuration. Hence this paper presents a simple and cheap shielding technique which consists in disposing an opportunely shaped ring around the volume which must be protected. This shielding ring can be placed above or under the soil surface. The analysis of the electromagnetic interaction between the overhead line conductors and the shielding ring is carried out by the electromagnetic theory. The current induced into the closed ring obeys to Faraday’s law and reduces the previous magnetic induction inside the volume.

Fig. 1 shows the several configurations of the HV line conductors considered in the analysis. The line conductors are placed at the minimum height suggested by the Standards for each case. At first a horizontal rectangular shielding ring is considered. This is located at different lateral distances D_S from the overhead line axis and at different heights h_S from the soil surface. The obtained results are expressed in terms of shielding effectiveness. In particular Fig. 2 shows the shielding effectiveness curves vs the lateral distance obtained when the rectangular ring (100x10 m^2) is positioned at D_S = 30-40m and h_S = 10 m and the HV line configuration is that one shown in Fig.1a). Curves of Fig. 2 are calculated in the middle transversal cross-section of the ring and on planes placed at different heights inside the volume to be protected. The shielding effectiveness is as greater as the observation plane is closer to the ring. However the shielding effectiveness obtainable by the proposed method is greater than the one obtained by other methods at the same distances. Fig. 3 shows the results of the same analysis carried out on the same ring placed under the soil surface (depth: 1 m). This solution could be adopted in proximity of areas used by children (schools, gyms,…).

The electromagnetic interference between the two above mentioned systems is systematically analysed for all the configurations of Fig.1 and by varying sizes and position (lateral distance and height) of the ring. Moreover the study is extended to a shielding ring inclined of a generic angle α with respect to the horizontal. Safety problems of the suggested shielding plant are also considered in the paper.

Results obtained by the shielding technique proposed in this paper are better than those ones given by the other methods and are compliant with the new exposure limits.

References

[1] IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz (Std C95.6-2002).

[2] ICNIRP "Guidelines limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)", Health Physics, 74(3), pp. 494-522, 1998.

[3] "Legge quadro sulla protezione dale esposizioni a campi elettric, magnetici ed elettromagnetici", Law n. 36, Feb. 22th, 2001, G.U. n. 55, March 2001.

[4] Bazzani A., Samanna M., Bosco M., "Analysis of a mathematical model to study reduction method in the emission of magnetic field produced by High-Voltage overhead power lines", EMC Europe 2002, Sept. 9-13, 2002, Sorrento, Italy, pp. 371-376.

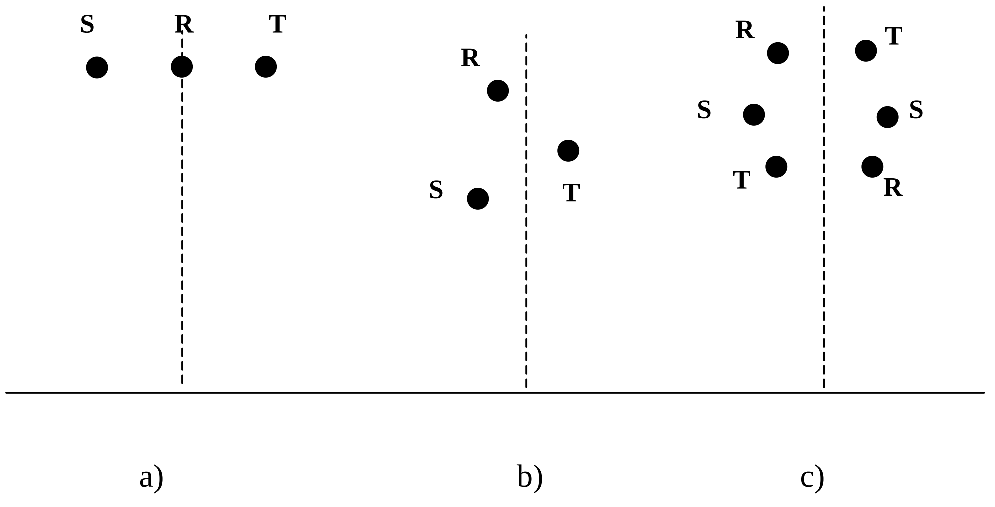

Fig. 1 – Adopted configurations of the transmission line:
a) 380 kV ; b) and c) 220 kV

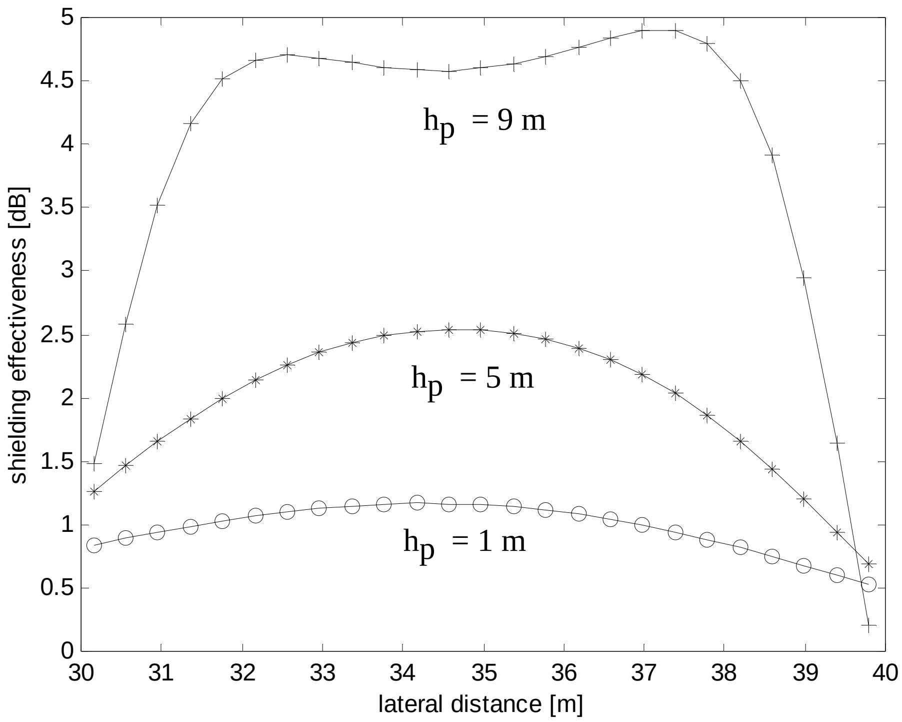

Fig. 2 - Shielding effectiveness vs lateral distance obtained when the rectangular ring (100x10 m^2) is positioned between 30-40m from the transmission line of Fig.1a) (380 kV ; 800 A) ; the ring height is h_s = 10 m; h_p is the observation plane height.

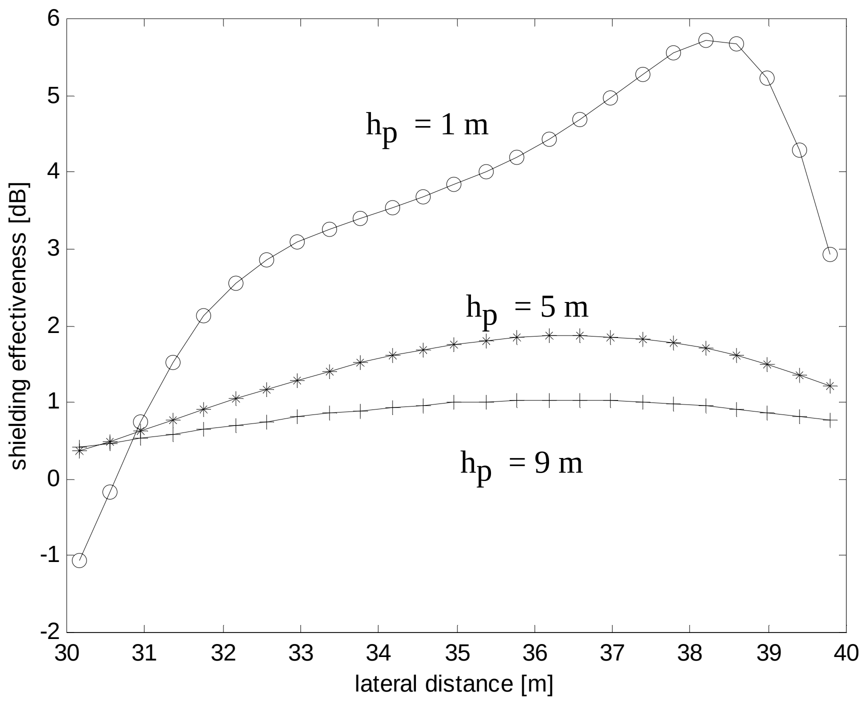

Fig. 3 – As Fig. 2 but the ring is positioned above the surface soil (depth = 1 m).