HUMAN BODY MAGNETIC EXPOSURE AND MAGNETIC INTERFERENCE WITH A TRACK CIRCUIT IN PROXIMITY OF A RAIL THERMO-ELECTRIC REGULATION SYSTEM

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A new patented technique for the Thermal Regulation of the Long Welded Rail during the laying down is being developed. It consists in heating the rail by Joule effect [1]. The heating of the rails is obtained by injecting a very intense rectified current in each rail by an equipment (called S.I.R.T.E.R. , Integrated System for Rail Thermo-Electric Regulation) which is placed on a wagon and is composed by a 900 kVA generator, an "inverted double-star" connected transformer, a diode bridge and a control system. The S.I.R.T.E.R. has been designed for working in a track renewal site while one track is operated. The injected current must be raised up to 10 kA and therefore it could be cause both of magnetic field human exposure in the working environment and of electromagnetic interference with the close track circuits.
This paper describes:

- EMC problems related to the S.I.R.T.E.R. working and the measurement procedures useful for characterizing its electromagnetic performance;
- a theoretical procedure for simulating the electromagnetic interference produced by S.I.R.T.E.R.

The electromagnetic behaviour of the S.I.R.T.E.R. has been tested by an experimental set up which has been assembled in MerMec railway laboratory. Tests have been carried out on a 108 m long track section. The S.I.R.T.E.R. wagon is placed at a end of this track section (working as killer circuit) while a little truck short-circuits the other end. Another track section (victim circuit) has been assembled in proximity of and parallel to the killer circuit. The inter-axis between the two circuits has been set equal to the standard railway distance. The following sets of measurements have been carried out:

a) measurements of magnetic induction (R.M.S. values) in several points (about 50) of the laboratory environment. The measurement points have been taken in proximity of and on the S.I.R.T.E.R. wagon, as well as along straight directions parallel to axis of the two circuits (at different heights from the soil);
b) measurements of magnetic induction spectra in some points of two vertical planes placed transversally to the axis direction (at two different heights from the soil: 1.0 and 1.6 m); Fig. 1 reports an example of magnetic induction spectrum measured on the killer circuit axis at 1.0 m height (see caption of Fig. 1 for details);
c) measurement of the current induced in the victim circuit.

Compliance of the measurements mentioned in a) with magnetic maximum permissible exposure levels suggested by IEEE Std [2] and by ICNIRP guidelines [3] has been obtained.

Moreover, the paper presents a FEM-based model of the track for calculating the magnetic field distribution caused by each harmonic of the measured source current. The agreement between FEM calculated harmonic values and the measured ones (measurements mentioned in b)) is very good. Fig. 2 shows the comparison between the measured values of B and the calculated ones for a frequency f = 308 Hz (details in the caption of Fig. 2). Analogous results have been obtained for the other harmonics. The calculated magnetic induction distribution becomes the input for an analytical procedure based on the electromagnetic theory and aiming to calculating the current induced in the close victim circuit. These so obtained induced current harmonics are in good agreement with the measurements mentioned in c).

Finally, Fig. 3 shows also the compliance between the above mentioned current harmonics and the "harmonic mask" (that is a frequency dependent limit value) imposed by the Italian Railway Regulation relative to the electromagnetic interference in the railway environment.

The obtained results allow us to apply this procedure to other hazardous situations.

References

[1] E. De Tuglie, G. Patrono, A. Picca, "A Particular Scenario of Electromagnetic Interference with Railway Signalling Circuits. A Contribution to improve System Safety and Reliability", 13th Mini-Euro Conf. and 9th Meeting of the EURO WG on Transportation, June 10-13, 2002, Bari, Italy, pp. 521-527.

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

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

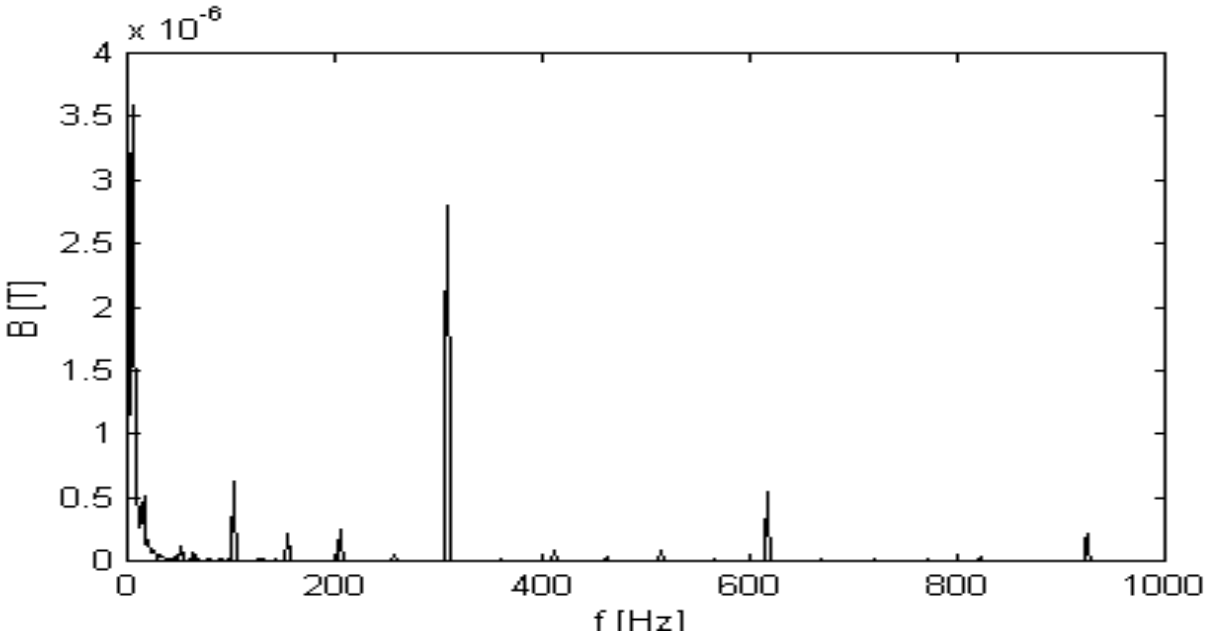

Fig. 1 – Magnetic induction spectra measured in axis with the railway section (killer circuit) at height equal to 1 m (source current average value 6 kA). Distance from S.I.R.T.E.R. equal to 35 m.

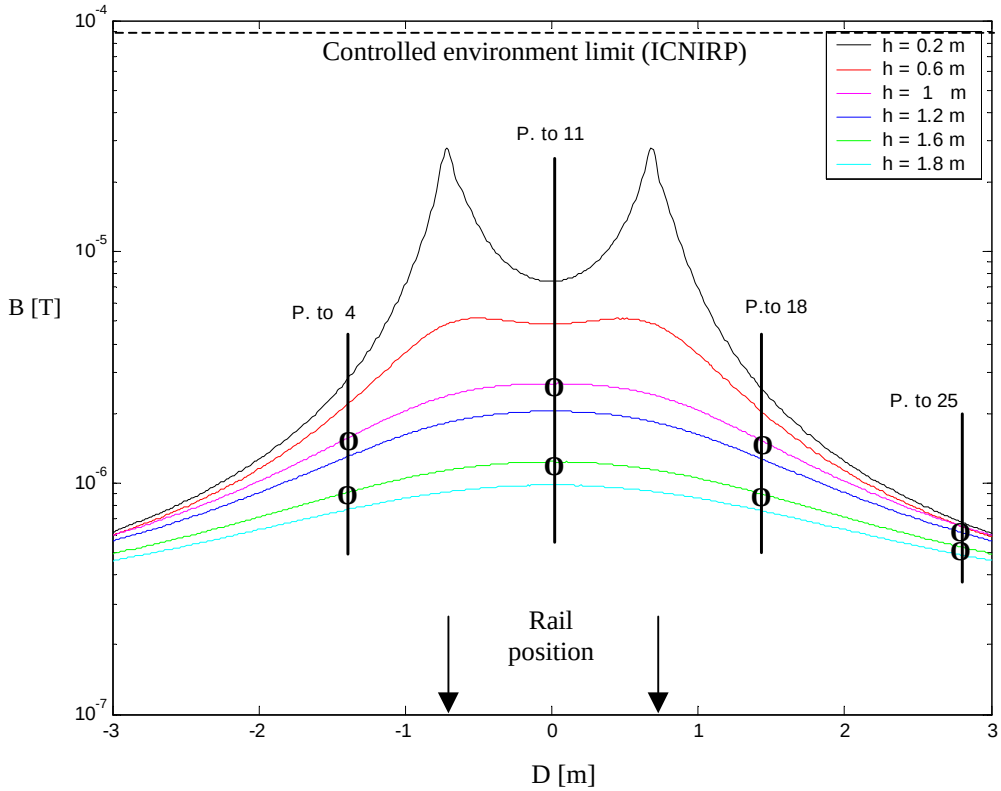

Fig. 2 – Comparison between magnetic induction values calculated by FEM (continuous lines) and the ones obtained by the measured spectra (o o o). The measurements has been carried out in several distances (points number 4, 11, 18, 25 here reported) of a plane placed transversally to the railway direction at two heights (1 and 1.6 m). The curves has been calculated for different height values. Data are referred to a frequency equal to 308 Hz.

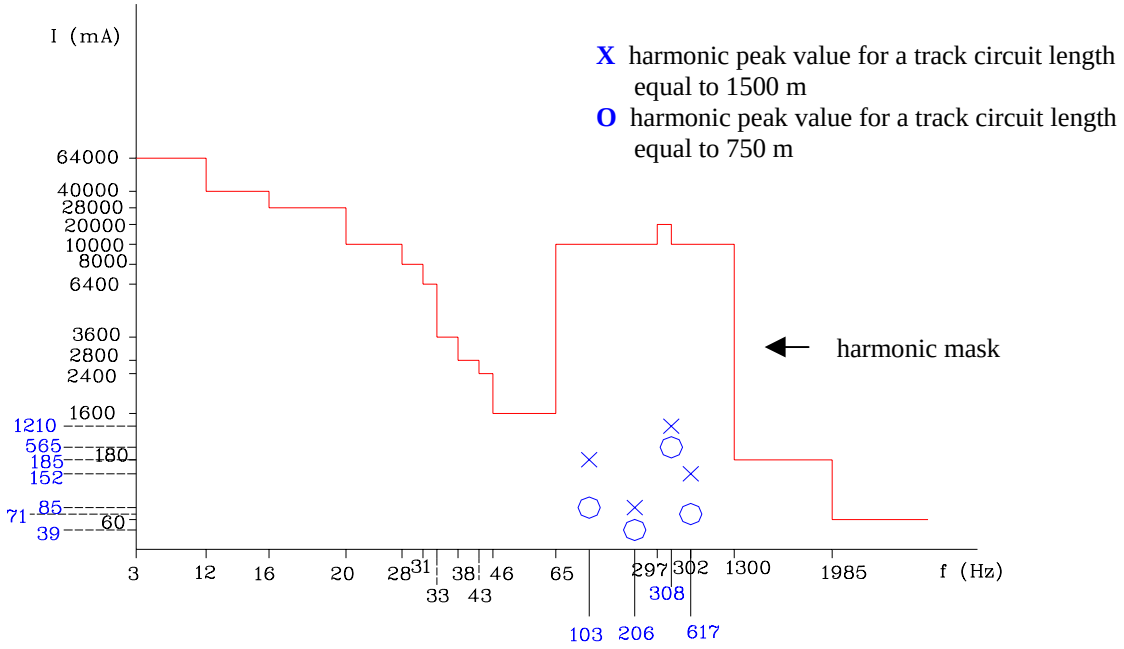

Fig. 3 – Compliance of the measured or simulated induced current harmonic peak values (o and x) with the harmonic mask of Italian Railway Regulation (continuous line).