Low Frequency Electromagnetic Fields In Power Transformer Rooms

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Abstract. In this paper it is presented experimental data on ELF magnetic and electric fields measured in a power distribution transformer room and in a room located above another transformer room. All the measurements were made at different heights. The first objective is to verify if in a specific installation international reference levels of such fields are exceeded. The second objective is to gather information on emanated electromagnetic fields originated on power transformers in order to allow future numerical simulation of such devices.

Keywords

Electric and magnetic fields, ELF, EMC, power transformers.

1. Introduction

There is a major concern in the public opinion about electromagnetic fields (EMF) in the vicinity of power transformers both in the inside and in the outside of transformer rooms.

These fields are mainly extremely low frequency magnetic fields (ELF), non ionizing radiation [1]. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines [2] and the European Council [3] recommend for the general public exposure to 50 Hz time-varying electromagnetic field the limit value of 100 μT for the flux density and 5 kV/m for the electric field. For worker exposure the limits are of 500 μT for the flux density and 10 kV/m for the electric field.

2. Studied Cases

In the presented work we have focused on the electric and magnetic fields measured in two different installations.

In the first case, a common transformer room, usually found in a residential or commercial area, was analyzed.

In the second case, measurements were made in a room above the power transformer room.

A. Transformer room

In this case we have focused on the electric and magnetic fields measured in the transformer room of the Electrical and Computer Engineering Department of the University of Coimbra. In this transformer room there are two distribution power transformers of 630 KVA, 15 kV/400 V, one of which is not usually connected to the power grid and is used for redundancy.

Fig. 1. Transformer cell and measuring instrument

The region of analysis was the 5×5 m area of the transformer room accessible with the transformer in charge, i.e. outside the transformer cells (see in figure 1 one of the transformers within its cell, being perfectly visible the low voltage power cables and, outside the transformer cell, the gaussmeter used in these measurements, standing on a non-ferromagnetic, non-conductive monopod). The electric and magnetic field (magnetic induction) have been measured in a grid layout with 0.5 m side, at the heights of 1.7 m, 1.5 m and 1.1 m,

corresponding to the typical height of the head, the heart and the pelvic region of a human body. See in figure 2, the transformer room with white marks on the floor at the places where measurements were performed, being visible the H. V. switchgear cells.

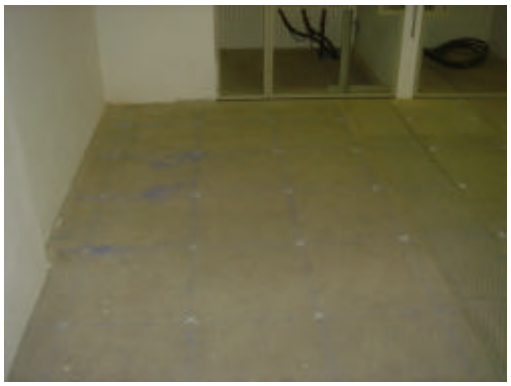

Fig. 2. Transformer room floor with grid marks where the measurements were performed

In order to collect data over different and significative transformer load periods, the load diagram has been analysed. In figure 3 it is presented the weekly load diagram of the transformer, plotted with 15 minutes intervals. The measurements were made over 3 different periods, all with load values above 50% maximum day load.

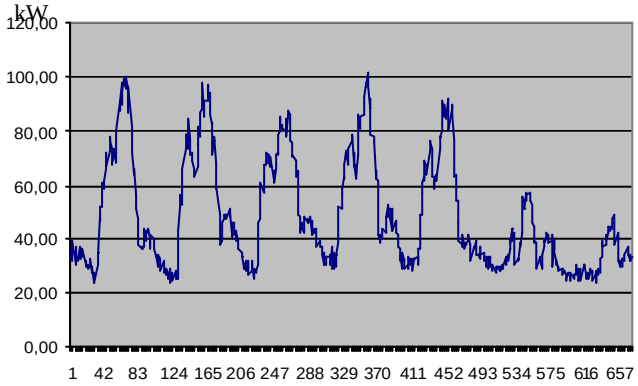

Fig. 3. Weekly load diagram of the transformer plotted with 15 minutes intervals

The measurements were made using a Sypris 4080 triaxial gaussmeter and a Aaronia Multidetektor II (figure 4).

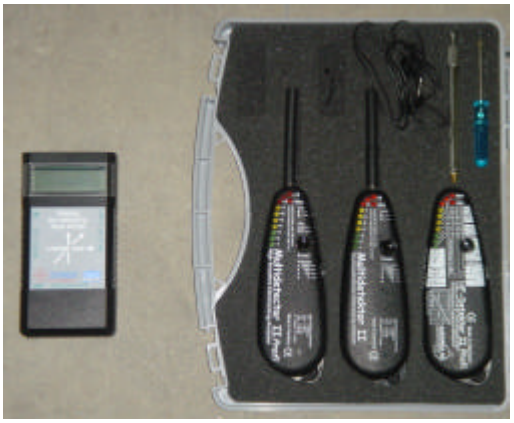

Fig. 4. Measurement equipment

B. Room above a transformer room

In the second case, it was measured the magnetic field in a room above the power transformer room in a commercial building. There has been a radiated EMC problem originated from a 1250 kVA, high voltage 15 kV, low voltage 400 V, Dyn5, dry cast resin transformer (figure 5) and its cabling system [4].

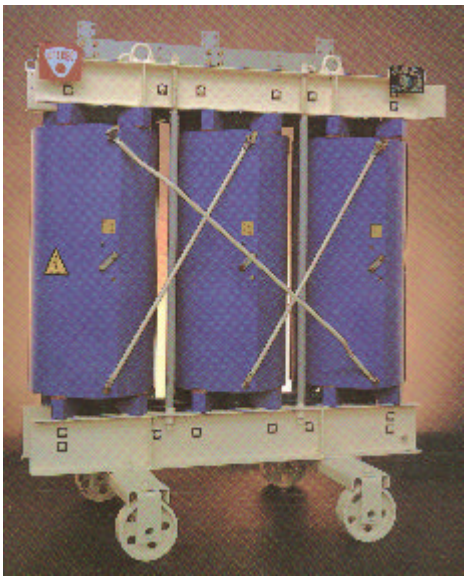

Fig. 5. Dry cast resin transformer

This dry transformer without enclosure has been installed in the basement and soon afterwards, in the room above, people working with computers started to complain about their CRT monitors flickering. This flickering was soon related to the electrical installation and the transformer in the basement below (see figure 6).

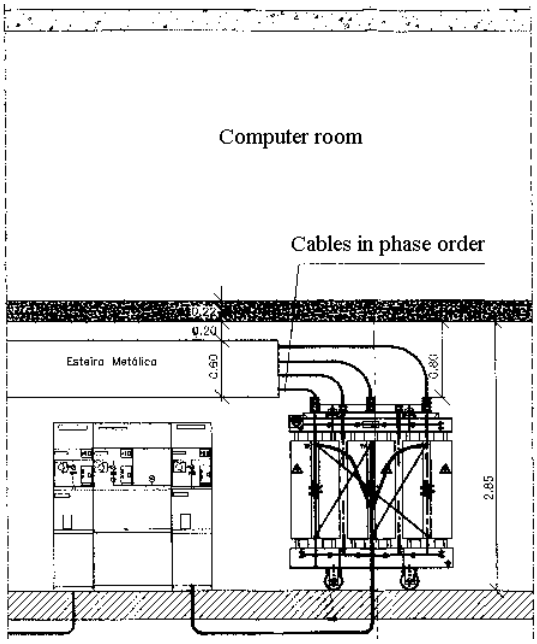

Fig. 6. Front view of the transformer and computer rooms

The magnetic field in the computer room was measured with a F. W. Bell 9900 gaussmeter and presented values up to 80 µT with the transformer at about one tenth of its nominal power. These values could easily lead to severe flux densities for loads near the full nominal rated power of the transformer.

The builder electrical subcontractor installed then a large (1.5 × 2.5 × 0.004 m) earthed iron plate (that acts as a magnetic shield) screwed to the ceiling above the dry transformer. He also changed the routing of the electrical cables of the secondary of the transformer.

The flux density in the computer room was measured again after the above changes have been implemented and, the same places where the maximum values were previously measured, above the iron plate, presented now values of less than 5 µT and in the remaining of the room there were measured values of less than 10 µT. These last measurements were made with the transformer at about 35% of nominal power and were taken one meter apart in a grid topology (figure 7) right above the floor and also at the height of one meter. There are no significant differences between the values measured at these two different heights. The flickering of the CRT monitors that revealed the EMC problem also disappeared. The unbalance of the phases and the neutral current were not considered significant.

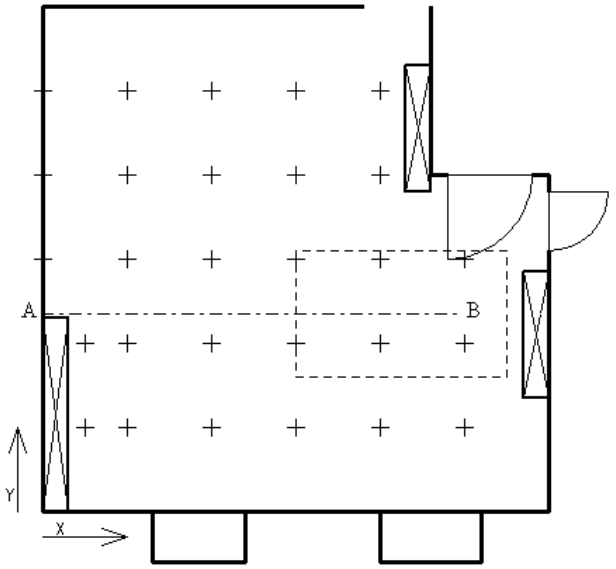

Fig. 7. Top view of the computer room with the spots of the measurements and the iron plate localization

3. Results

A. Transformer room

In figure 8 and 9 is presented the electric field distribution measured at 1.7 m, at about 2pm, in the transformer room of the first installation. The maximum electric field is about 200 V/m and was measured near the HV switchgear, which is within a cell. Near the transformer the electric field is very low (less than 5 V/m) because the HV side of the transformer is at the back, against the wall. It was verified that at 1.5 and at 1.1 m the electric field is lower than 200 V/m. These values are far from the 5 kV/m limit.

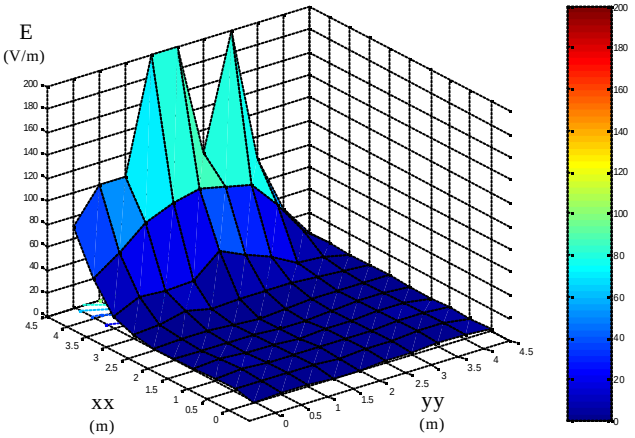

Fig. 8. Electric field distribution at 1.7 m, at about 2 pm

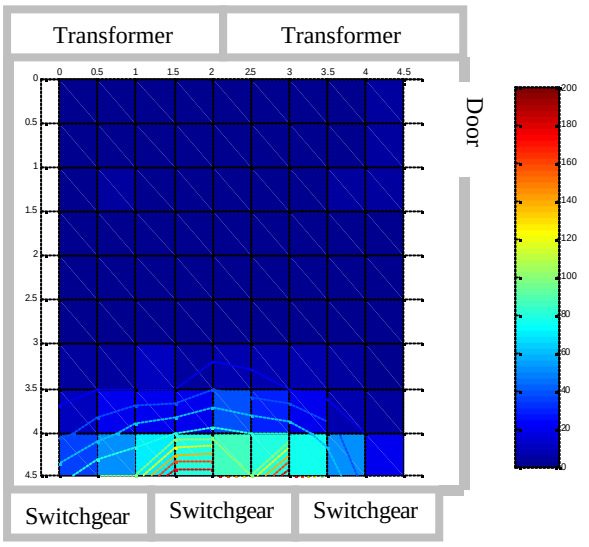

Fig. 9. Room transformer layout with the electric field (in V/m) distribution at 1.7 m, at about 2 pm

In figure 10 and 11 is presented the magnetic induction distribution measured at 1.1 m, at about 3:30 pm. The maximum magnetic field is about 50 µT. It was verified that at 1.7 and at 1.5 m the magnetic field is lower than this. These values are about half the recommended 100 µT limit. We would like to notice that this maximum measured values were verified at a specific spot of the transformer room (near the low voltage output cables) and that in the rest of the transformer room area the magnetic induction measured values are more than ten times lower.

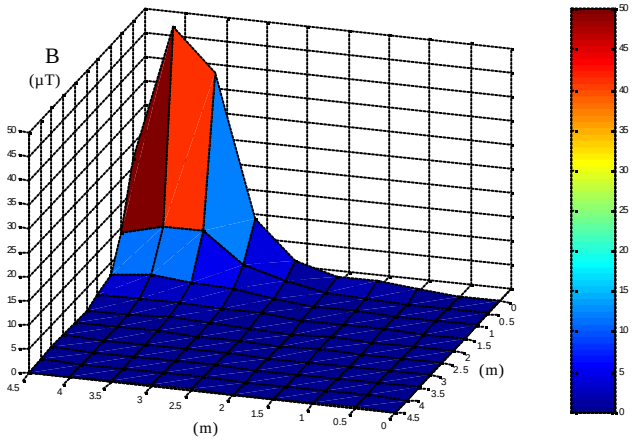

Fig. 10. Magnetic field distribution at 1.1 m, at about 3:30 pm

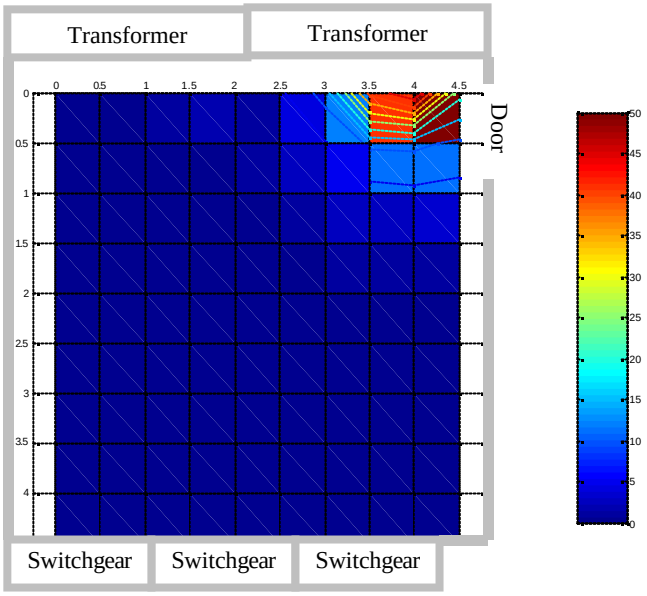

Fig. 11. Room transformer layout with the magnetic field (in µT) distribution at 1.1 m, at about 3:30 pm

B. Room above a transformer room

In figure 12 and in figure 13 are presented contour plots of the amplitudes of the magnetic induction in the computer room floor and one meter above that floor respectively, after the iron plate installation and the cable layout changes.

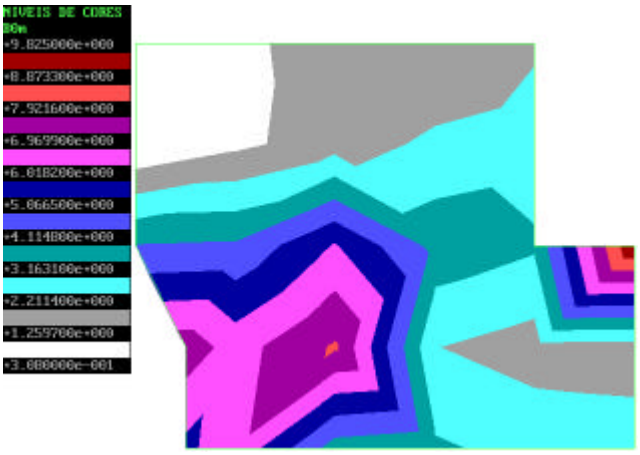

Fig. 12. Amplitudes of the induction B right above the room floor

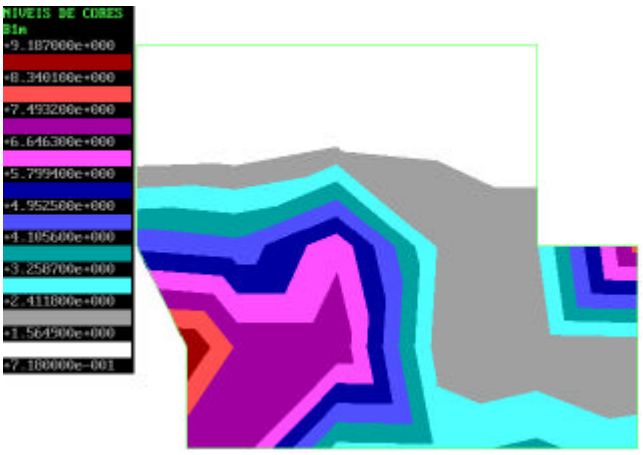

Fig. 13. Amplitudes of the induction B 1 m above the room floor

In figure 14 and 15 are presented the variation of the magnetic induction along a line above the transformer center plane above the computer room floor and one meter above that floor respectively, after the implemented changes.

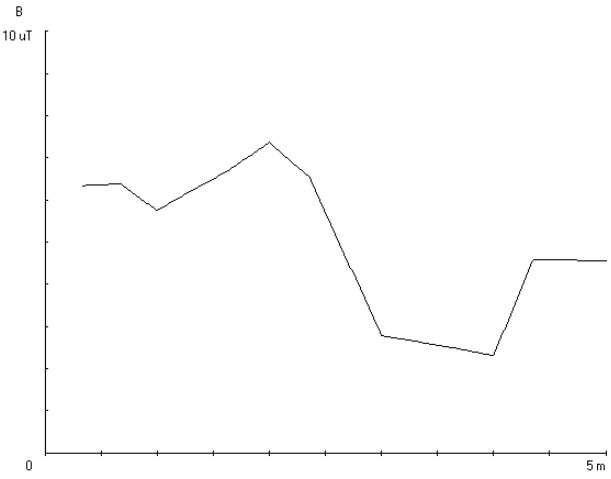

Fig. 14. Variation of the magnetic induction along the center line A-B above the transformer in the computer room floor

In this figures it is clearly seen the magnetic shield effect of the iron plate. There are no significant differences in the magnetic field distributions just above the computer room floor or one meter above it.

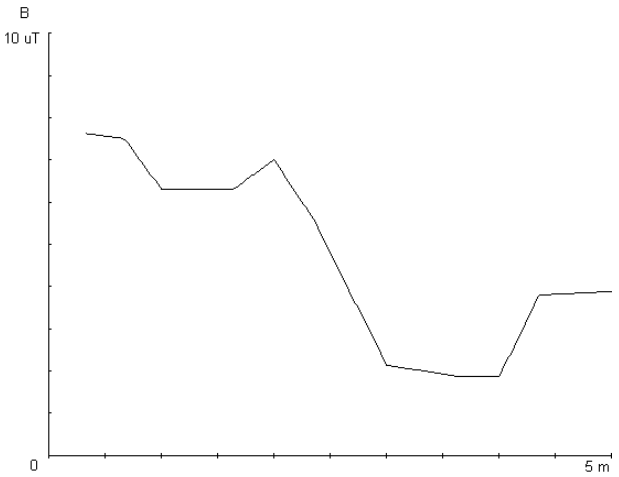

Fig. 15. Variation of the magnetic induction along the center line A-B, 1m above the computer room floor

4. Conclusions

In some situations (that we believe are the most common) the levels of the electric and magnetic fields are well below the recommended limits while in some other situations the levels are of the same order of magnitude of the recommended limits or are even higher than those limits and some curative action must take place. The measured results tend to indicate the importance that the cabling system layout may have to the overall magnetic field emanated.

Outside the cells, the emanated magnetic field is more important than the electric field, which correspond to the expectations. Indeed, the electric field is easily attenuated by interposing grounded common conducting objects, whereas the magnetic field penetrates in those materials and is more difficult to reduce.

References

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[2] *Electromagnetic Fields*, World Health Organization (Regional Office for Europe) pamphlet, 1999.

[3] European Council Recommendation 1999/519/CE, relative to exposition of the population to electromagnetic fields (0Hz to 300GHz), July, 12, 1999.

[4] L. Antunes, A. P Coimbra, *EMC Problems with Dry Cast Resin Transformers – A Case Study*, Book of Digests of the 16th International Conference on Electrical Machines, ICEM 2004, Vol. 3, pp. 909-910, 5-8 September, 2004, Cracow, Poland.