Magnetic Radiation of Low Frequency Installations

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This article is a summary of presentations ([1] and [2]) of Daho Taghezout (Applied Magnetics, Switzerland), Nadia Nibbio and Philippe Chollet (Romande Energie, Switzerland). For complete presentations, email: *software@cedrat.com*

FLUX *is a finite element software application used for electromagnetic and thermal simulation, both in 2D and 3D. It can handle the design and analysis of any electromagnetic device. Based on 30 years of experience,* FLUX *is reliable and accurate, featuring a large number of functionalities: multi-parametric analysis, extended import capabilities (STEP, IGES...), and mixed meshed generation [3].* FLUX *is developed by CEDRAT Group in France. The Manitoba HVDC Research Centre has been in partnership with CEDRAT since 2002, and has been investigating co-simulation possibilities and model parameter extraction for* PSCAD® *based transient simulations.*

Regulations in Switzerland ONIR (Order on Non-Ionising Radiation protection) defines exposure limit values for electric and magnetic fields. They can be found on the website: *www.umwelt-schweiz.ch*. A brief summary is given in Table 1. In order to meet these restrictive regulations, simulations and measurements have been carried out to evaluate the efficiency of actual equipment. Thanks to those measurements and simulations, improvements have been made to equipment to comply with current regulations.

Magnetic field simulations with FLUX FLUX [3] has been used to model various configurations of electrical equipment and evaluate radiated magnetic and electric fields: three-phase overhead lines, power cables, distribution transformers and a complete MV-LV distribution station. Results are presented for overhead line and distribution station. Two configurations of overhead line have been modelled as presented in Figure 1. The field distribution proves to be very dependant of the phase distribution as shown in Figure 2.

Exposure limit values for the frequency ranges of selected installations:

Installation		Exposure limit value
Railways	16 2/3 Hz	300 µT; 10 000 V/m
High-voltage power lines	50 Hz	100 µT; 5 000 V/m
Radio broadcasting transmitters	10-400 MHz	28 V/m
Mobile telephone	900 MHz	41 V/m
Base stations	1800 MHz	58 V/m
UMTS base stations	2100 MHz	61 V/m

Installation limit values within the frequency ranges of selected installations:

Installation		Installation limit value
Railways		1 µT (24 hr mean)
High-voltage power lines		1 µT
Radio broadcasting transmitters		3 V/m
Mobile telephone	900 MHz	4 V/m
Base stations	1800 MHz	6 V/m
UMTS base stations	2100 MHz	6 V/m

Table 1 Exposure Limits.

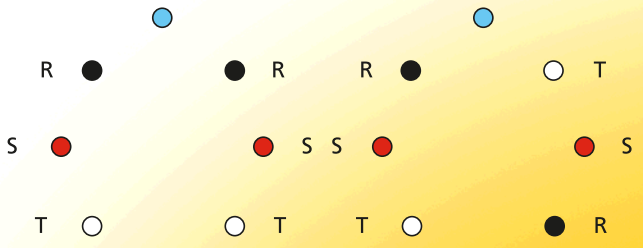

Figure 1 Modelled configuration (uniform and optimized phase distribution).

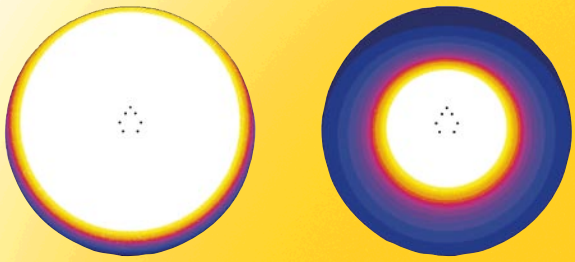

Figure 2 Magnetic field distribution for uniform and optimized phase distribution.

The distribution of the field on the ground level can then be evaluated as in Figure 3. A MV-LV distribution station is essentially made of three radiating parts: transformers, cables and a switchboard. All parts have been modelled and their influence has been evaluated in the field generation. We can see in Figure 4 that the 1 µT limit is at 12 m above the station ground level. Figure 5 also shows the magnetic field on walls of the station: it is indeed higher than 1 µT.

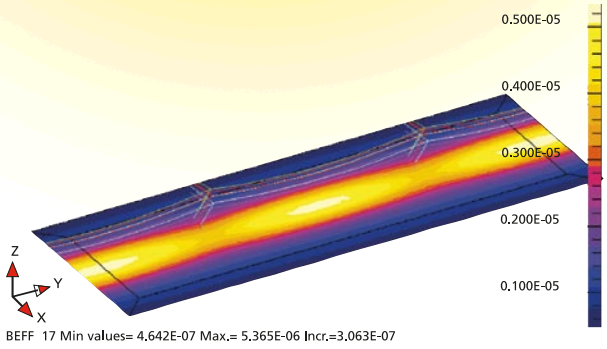

Figure 3 Ground level magnetic field.

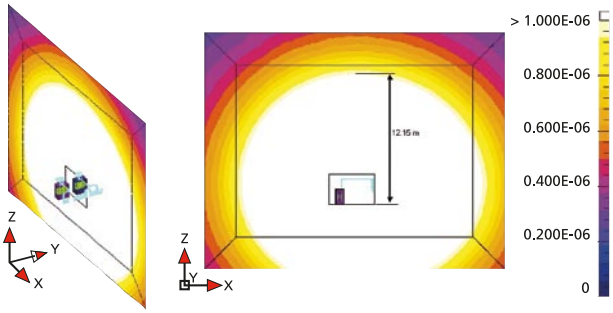

Figure 4 Magnetic field distribution on a vertical section between both transformers.

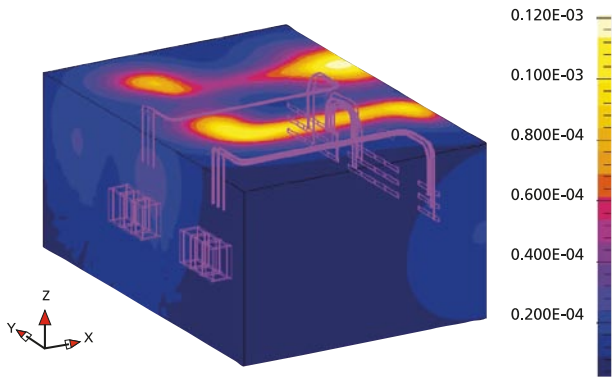

Figure 5 Magnetic field on walls of station.

Improvements and new measurements

From these simulations, improvements have been proposed, such as reducing the current per cable (parallel power transmission), increasing the space between source and influence zone, reducing space between phases and phase-neutral line, avoiding long cable connections, magnetic shielding of distribution boards, etc. Some have been carried out to follow the Swiss regulations as can be seen in Figure 6.

Figure 6 Low voltage electric board before and after modifications.

Those changes have greatly influenced the magnetic radiated field in the station, as shown in Figure 7.

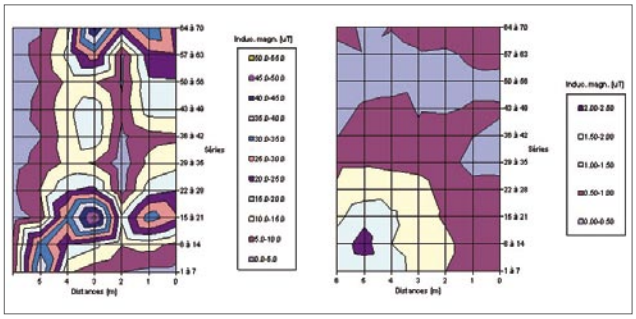

Figure 7 Comparitive measurements before and after modifications.

Conclusion It has been observed that simulations carried out with FLUX could help optimize magnetic field radiation of electrical equipment, in order to follow exposure regulations. Various modifications have been proposed thanks to the simulations. Some of these were implemented and showed significant results on comparative measurements.

References

[1] "Magnetic radiation of lf installations", Daho Taghezout, Nadia Nibbio; presentation at FLUX Users Conference 2004, Grenoble, France
[2] "Magnetic field radiated by low voltage electrical equipments", Philippe Chollet, Nadia Nibbio; presentation at FLUX Users Conference 2007, Lyon, France
[3] More information about FLUX at *http://www.cedrat-groupe.com/* or *software@cedrat.com*