

MAGNETIC FIELD COMPUTATION DUE TO HIGH VOLTAGE POWER LINES USING EasyMAG

Tony Richard O. Almeida⁽¹⁾, Carlos F. R. Lemos Antunes⁽²⁾

Laboratório de CAD/CAE ^(1,2), I.S.R.⁽¹⁾

Departamento de Engenharia Electrotécnica e de Computadores, Universidade de Coimbra
Pólo 2 – Pinhal de Marrocos, 3030-290 Coimbra, Portugal

⁽¹⁾tony@deec.uc.pt, ⁽²⁾lemons.antunes@deec.uc.pt

Abstract – The vicinity of residences to overhead power lines has been a factor of concern for public health. Several studies have been developed in order to establish a relationship between the magnetic fields due the power lines and the health of people. In this paper it is presented a magnetic field computation using the software tool EasyMAG developed by the authors [4], considering several overhead power lines configurations. The software runs under Matlab© environment. One of the configurations considered was the 60kV overhead power line which goes over the Electrical and Computer Engineering Department at the University of Coimbra. This line is right over the Library so there was the particular interest to observe if the international reference levels for the magnetic field are not exceeded. For all the cases considered in this paper it is observed that the values obtained are far below the maximum limit of 100 μ T.

Keywords – Magnetic Fields, Power Lines, ELF, Magnetic Field Modeling.

1. Introduction

Since late eighties a growing concern over possible health effects from 50-60Hz magnetic fields emerged and became a matter of several scientific studies. Research work suggested a link between these kinds of fields and certain forms of leukemia and brain cancer, and also several biological disorders [1] [2] [3]. These studies reveal a particular attention to magnetic fields due to power lines, in particular the relationship between public health and the proximity to power lines. The need for an accurate evaluation of the magnetic field arising from these electric power lines becomes obvious.

Regarding this magnetic field evaluation, the authors developed a software application for simulating and calculating the magnetic field during the design of domestic/industrial electrical installations [4]. From a 3D representation of the structure, stored in a dxf file (design exchange format file) usually created in a CAD

application, which includes the layout of the electric wiring, and considering the current in the electrical circuits (indicated by the user), the software evaluates the magnetic field intensity for power-line frequencies at different heights. With only a few adjustments this software can also be used in the simulation of magnetic fields due to high voltage power lines.

In this paper there were considered two different situations. First a validation of the solution presented is made by comparing the results with analogous work carried on by Garrido et. al [5]. Finally a simulation of the 60kV power line which goes over the Electrical and Computer Engineering Department at the University of Coimbra is made.

In conclusion, the values obtained from simulation are compared with those imposed or recommended by international regulations, in particular, the 100 μ T maximum limit recommended to exposition of population [6].

2. Configuration of the models

Due to the limitation of representing a catenary or even a parabolic curve using a CAD software (in this particular work the authors used AutoCAD© for creating the models), the power line representation was made using straight lines. It is important to notice that all the models created are three-dimensional models.

First there were created models for two different kinds of 132kV overhead power lines:

- i) a double-circuit line (one to each side of the tower) with phases in parentheses (Fig. 1a). This circuit is lightly unbalanced with means rms current values of 91A in one circuit and 104A in the other.

- ii) a single circuit with three conductors placed at the same height (Fig. 1b). The mean rms value of the current considered is 482A.

For these overhead power lines there was no information available about their plan-profile so they were modeled as straight 3D conductors with constant height.

Thereafter it was considered the model of the 60kV overhead power line. For this line, details of the plan profile were provided by the electric utility, EDP – Electricidade de Portugal, allowing a more realistic approach to the model.

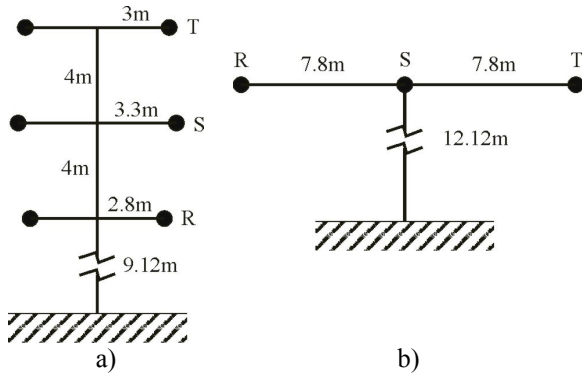


Fig. 1. Cross section of the power lines: a) double circuit; b) single-circuit

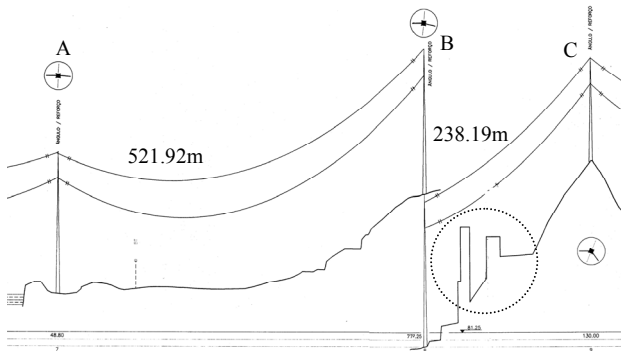


Fig. 2. Extract of the plan-profile for the 60kV power line (courtesy of EDP)

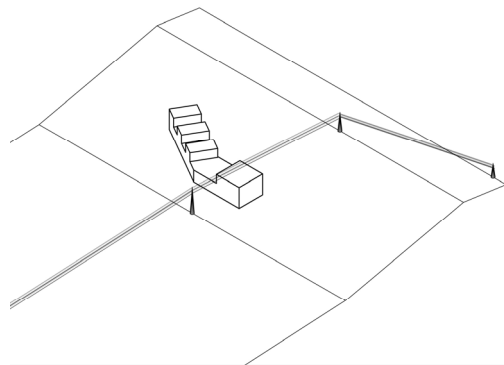


Fig. 3. Location of the Electric and Computer Engineering Department and the 60kV overhead power line

This overhead power line, known as Pereiros – Alto de S. João 60kV power line, is about 4km long and is placed in

a rough terrain. The interest of this work is on the length of the line that crosses the area of the Pólo 2 of the University of Coimbra where the Electrical and Computer Engineering Department is located.

In Fig. 2 it is presented an extract of the plan profile for the overhead power line under study (courtesy of EDP). It is easily noticed the roughness of the terrain. Also, the Electrical and Computer Engineering Department building's profile is depicted (dotted circle). In Fig. 3, is depicted a simple graphical representation of the location of the building and the overhead power line.

As in the first case, this is a double circuit power line. Along the length considered for simulation the power line has the same cross-section (Fig. 4). Once again, the power line was modeled as 3D straight lines between each pair of towers. Two different situations are considered within this case. First the model was run considering the maximum value of current (770A) in both circuits. In a second stage it was considered only 60% of the load (462A).

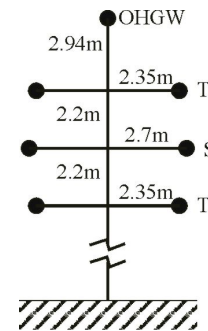


Fig. 4. Cross-section of the Pereiros – Alto de S. João 60kV power line at Electrical and Computer Eng. Dpt., UC (courtesy of EDP)

3. Results and Discussion

In this section the results are grouped in two subsections. The first group is concerned with the 132kV overhead power line models. These results are used to validate the application developed for the magnetic field calculation due to the overhead power lines

The second group of results is obtained from the 60kV overhead power line case study. The authors intend to calculate the magnetic field at the Electrical and Computer Engineering Department and compare the values obtained with the maximum admissible legal values (100 μ T), particularly in the reading room of the Library, which is located at the top of the building, so close to the power line considered.

All the models created were used to calculate the magnetic field due to the power lines over a period, i.e., over an interval of 20ms (50Hz). The results are presented considering the IEEE measurements procedure [7].

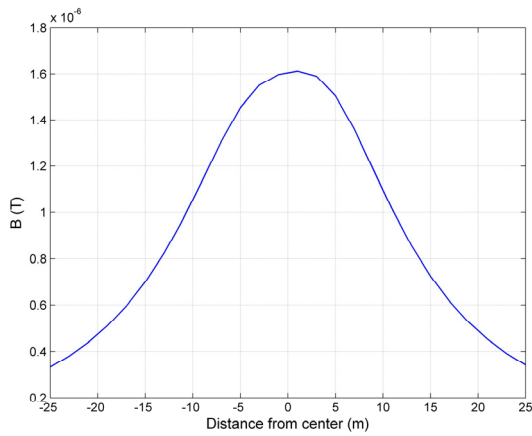


Fig. 5. Computation of the resultant magnetic field under a 132kV double-circuit power line at middle-spam

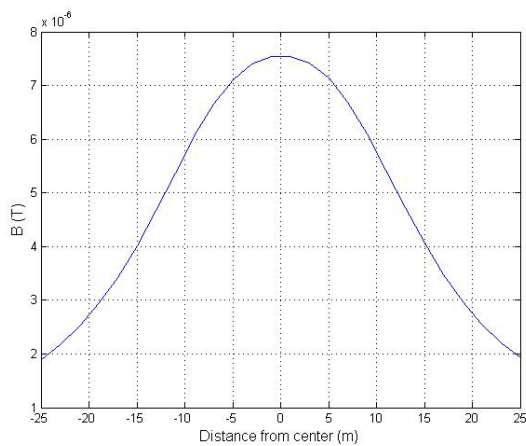


Fig. 6. Computation of the resultant magnetic field under a 132kV horizontal single circuit power line at middle-spam

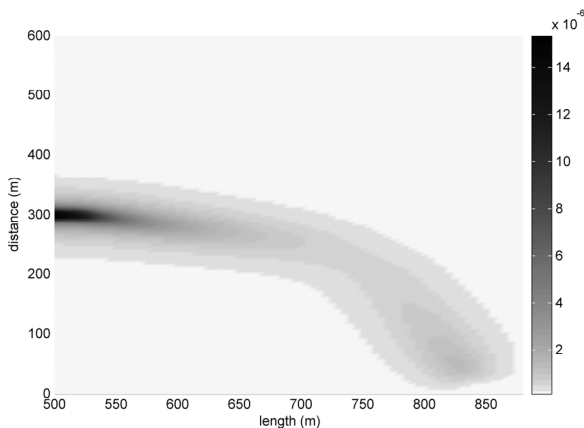


Fig. 7. Resultant magnetic field at Library's elevation (T)

A. 132kV Overhead power lines

The values presented in this section were obtained at the height of 1 meter. In Fig. 5 is presented a graphical representation of the resultant magnetic field obtained for the double circuit power line as a function of the distance to the center of the line, obtained at middle-spam of the power line. As expected, the maximum value of the magnetic field is obtained right at the center of the power line configuration.

In this case it is observed that the magnetic field's maximum value is $1.6\mu\text{T}$. In Garrido et. al [5], for a similar power line, the maximum value obtained by simulation was almost $1.6\mu\text{T}$ and by measuring was close to $1.8\mu\text{T}$.

Similar, Fig. 6 presents the resultant magnetic field obtained for the horizontal single circuit power line as a function of the distance to the center of the line. Once again the maximum value occurs at the center of the power line configuration, with a value of $7.56\mu\text{T}$. Garrido et. al [5] presented a resultant magnetic field of approximately $7.5\mu\text{T}$ for both simulated and measured values.

The values obtained in the simulations in both different cases are practically identical to those obtained by simulation and measurement in the work of Garrido et. al. By this, the authors also concluded about the goal reliability of the software tool developed.

B. 60kV Overhead power line

In Fig. 7 is presented the resultant magnetic field due the overhead power line at the Library's reading room elevation plus one meter (108.75m). This room is one of the highest rooms of the building and it is located right below the power line.

The whole model was created inside a box with 880m length, 600m width and 200m height. The tower A (Fig. 2) is located at the origin of the abscissa and at ordinate 300m . The graphic in Fig. 7 presents only values of magnetic field for abscissas higher than 500m (towers B, C and D). Due to the fact that the conductors are no longer at constant height, it is possible to observe that the magnetic field varies along the power line, reaching higher values at coordinate (500m , 300m): at this point the plane $z = 108.75\text{m}$ is close to the power line.

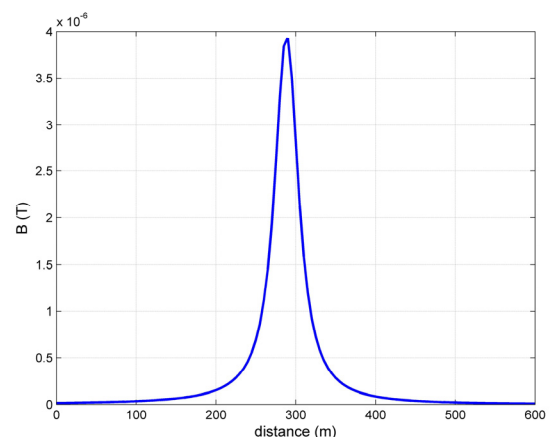


Fig. 8. Representation of the magnetic field at elevation 108.75m and length 575m

In Fig. 8 it is presented a cross-section of the surface representation in Fig. 7, which corresponds to a graphic obtained at the plane of abscissa 575m , right in the middle of the Library. It is possible to observe that the maximum resultant magnetic field is $3.93\mu\text{T}$, a value

very inferior to the maximum limit of $100\mu\text{T}$. It should be noticed that this and the following values do not consider any kind of attenuation due to the building structure and thus they might be lower. These values can be seen as a “worst-case” scenario.

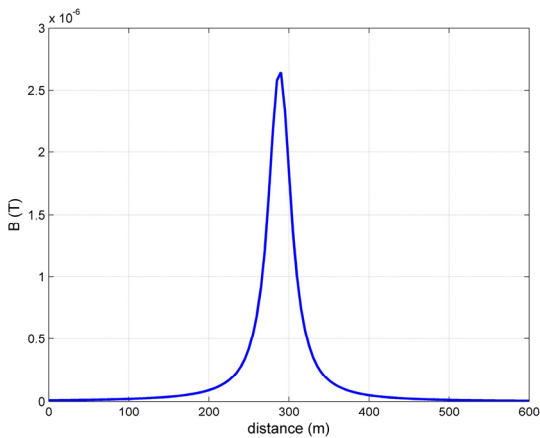


Fig. 9. Representation of the magnetic field at elevation 108.75m and length 575m (60% of maximum power load, 462A)

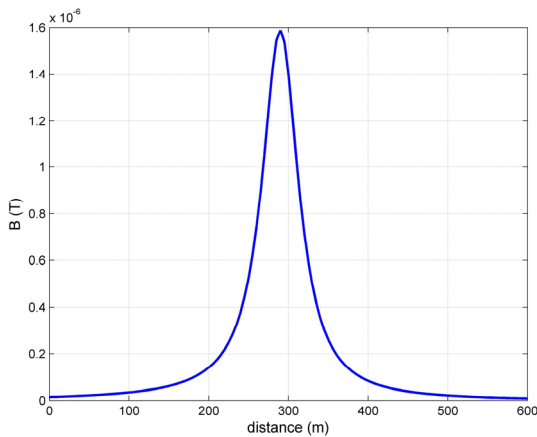


Fig. 10. Representation of the magnetic field at the elevation of the offices in floor 3A (abscissa 570m)

In Fig. 9 it is presented a graphic for the same abscissa and elevation, considering only 60% of the maximum power load. In this case the maximum magnetic field reaches the value of $2.64\mu\text{T}$, which corresponds to a reduction of practically 33% of the value verified with full load.

Finally, in Fig. 10 is presented a graphic for the magnetic field at the elevation of the professor’s offices (floor 3A, abscissa 570m). These offices are closer to the power line but they are located a few meters from the center and at a lower elevation ($95.75\text{m} + 1\text{m}$). In this case the maximum value for the resultant magnetic field is $1.59\mu\text{T}$. Once again, far below the maximum value of $100\mu\text{T}$.

4. Conclusions

This work involved the computation of the magnetic field generated by 132kV and 60kV overhead power lines using a software application developed which runs under

Matlab© environment [4]. This application was created initially for the magnetic field calculation due to the electrical wiring in domestic/industrial electrical installations.

This study has two significant goals that, according to the authors, were achieved: (i) to validate the results obtained with the software; and (ii) verify the degree of compliance with European Recommendations on magnetic field limitation within a designated building, in this case, the Electrical and Computer Engineering Department of the University of Coimbra.

A comparison between the results obtained in this work with a similar work over the 132kV power lines shows a clearly convergence of results. Thus, the developed software application is a valid tool for the study of magnetic fields in different situations. It can be used as a support in the transmission line planning in the prevention of “black spots”, where the magnetic field may violate the international recommendations on magnetic field limitations.

In the analysis of the 60kV overhead power line, the results tend to indicate that at the Library’s reading room of the Electrical and Computer Engineering Department, although significantly close to the power line, it presents values for the resulting magnetic field that are on the safe side, thus far away from the $100\mu\text{T}$ recommended by the EU. This was also verified in the offices near by the power line but located at lower heights. It should be pointed out that these results do not consider any attenuation due to the building or other externalities. Some difficulties arise when considering the comparison of the simulated results with measured values at the rooms considered in this study because the authors could not access to the real-time information about the load in the power line.

Finally, one of the limitations with the actual software is the fact that only straight overhead power lines can be considered. The authors intend, in future works, to introduce modifications that would allow the representation of power lines with catenaries or parabolic curves.

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