A Study of Electromagnetic Field Generated by High Voltage Lines Using Comsol Multiphysics

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***Abstract*— Possible harmful effect of the low frequency electric and magnetic field on human health. This paper investigates using the COMSOL MULTIPHYSICS software modules in calculating the electromagnetic fields generated in the vicinity of High Voltage (HV) power transmission lines. The presented results in this paper demonstrate the effectiveness of using the electrostatic and magneto static modules of the COMSOL MULTIPHYSICS in electromagnetic fields calculation at many levels near power transmission lines. The resulting fields are compared with the International Commission on Non Ionizing Radiation Protection (ICNIRP) field guidelines .**

Keywords-component; formatting; High voltage; power transmission lines; Electromagnetic field; Finite element method; Electromagnetic compatibility; Low frequency.

I. INTRODUCTION

Over the last few decades, many studies have been undertaken in an attempt to analyze the potential health hazards that may arise from human exposure to low frequency electric and magnetic field. The interactions of these fields with the living organisms are still open for many researchers worldwide because of the results of a number of laboratory and epidemiological studies, which indicate possible harmful effects [1-2]. or no risks [3-4]. A number of international organizations have formulated guidelines establishing limits for occupational and general public electric and magnetic fields exposure. Among these organizations, are the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines [5], IEEE [6] and the National Radiological Protection Board (NRPB) [7] guidelines .A particular interest is given to the negative effects of electric and magnetic fields generated by the electric power transmission lines, so that it's very important to evaluate the electromagnetic pollution near of this source. This can be analytically and practically carried out using analytical methods or measuring instruments [8-9], also different numerical methods can be used for the calculation of electric and magnetic field around transmission lines [10-15].

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In this paper the COMSOL MULTIPHYSICS software electrostatic and magneto-static modules are being used in calculating the electric and magnetic field generated in the vicinity of HV transmission lines. This software is based on the finite element method, which has proved its effectiveness over other numerical methods in the context of modeling of electromagnetic phenomena [16-18].

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II. CHARACTERISTICS OF THE STUDIED MODEL

The model considered is 220 KV high-voltage line Fig. 1.

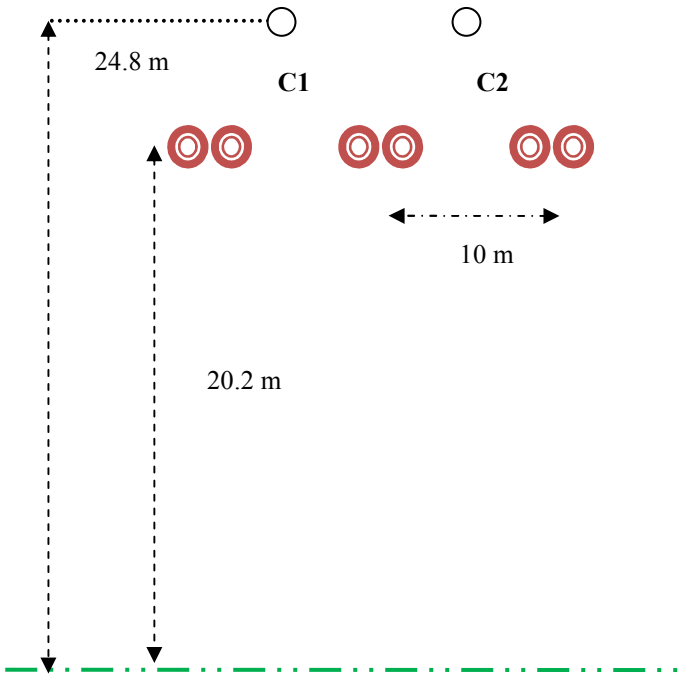

Fig. 1.Geometry of studied model

- Voltage level is 220 kV line-to-line rms voltages .

- Each phase consists of two conductors, 1.144 cm diameter each and spaced by 40 cm.
- The distance phase conductor to the ground is 20.2 m .
- The distance guard cable to the ground is 24.8 m.
- Separation between each two adjacent phases is 10 m.

III. MODELING OF ELECTRIC AND MAGNETIC FIELDS

The numerical simulation is performed by the software COMSOL MULTI PHYSICS 2D. An Electrostatic and Magneto-static modules of COMSOL have been used to determine the values of the electric and magnetic fields.

The steps for calculation are described in the diagram of Fig. 2.

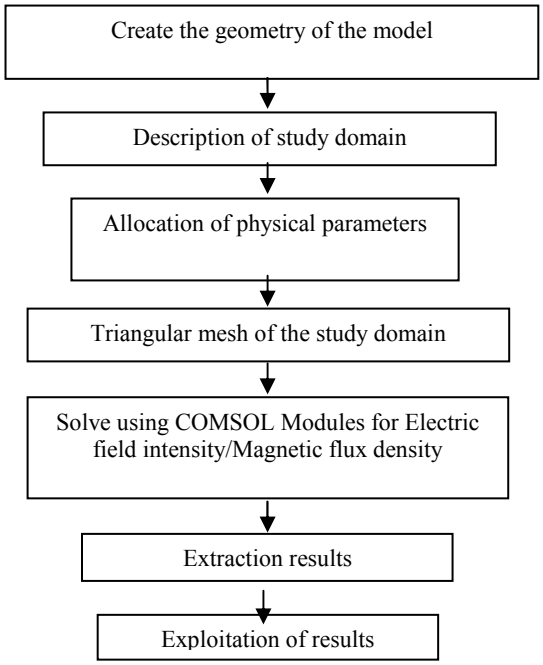

Fig. 2 Steps for calculations process.

IV. RESULTS

The results show the lateral distribution of electric and magnetic field at several levels in the overhead power line.

The starting point (x = 0m) represents the center phase of the line , The electric and magnetic field has been calculated at a longitudinal distances up to 60 m (± 30 m from the starting point) at several levels above the ground (0m to 30 m) .

A. Behavior of electric field

Fig. 3 shows the two-dimensional plot of the electric field distribution for the three following levels: the ground (0 m), exposure of the heart (1,5m) and brain exposure (1.8m).

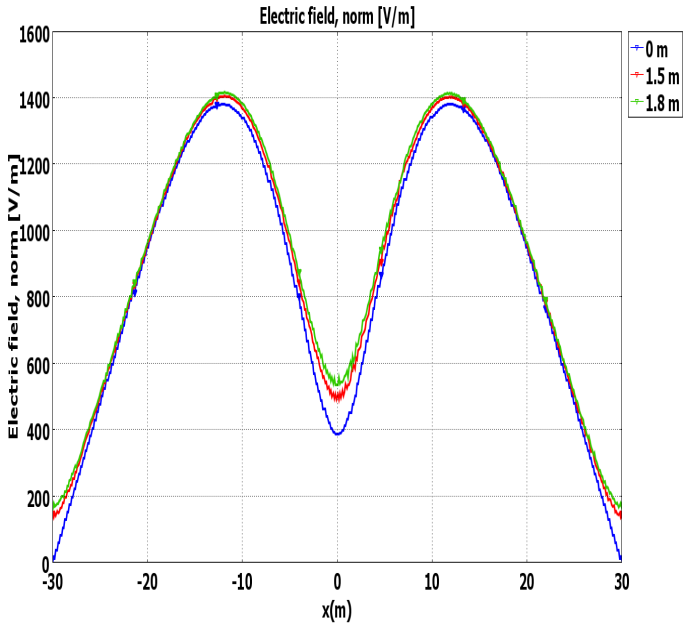

Fig. 3. Lateral profiles of electric field for levels (0m-1.5m-1.8m)

Other levels have been considered, Fig.4 visualize the profile of the electric at level between 2m to 19m above the ground. For good visualization of the results we plotted the results on two curves.

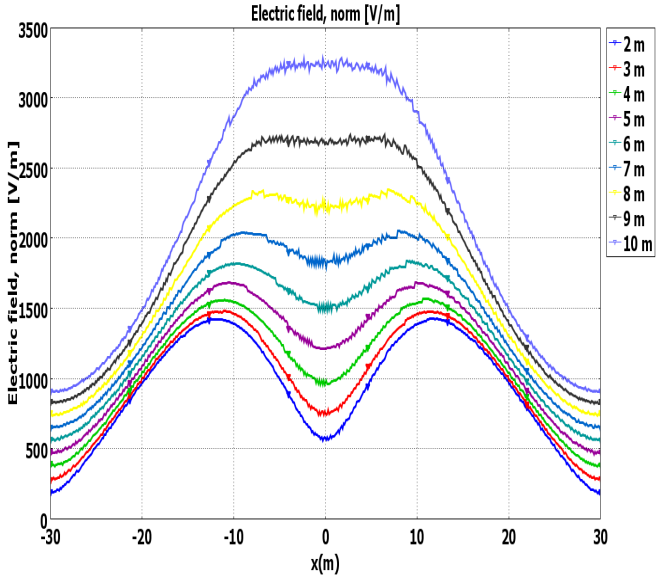

Fig. 4. Lateral profiles of electric field for the levels between 2 to10m

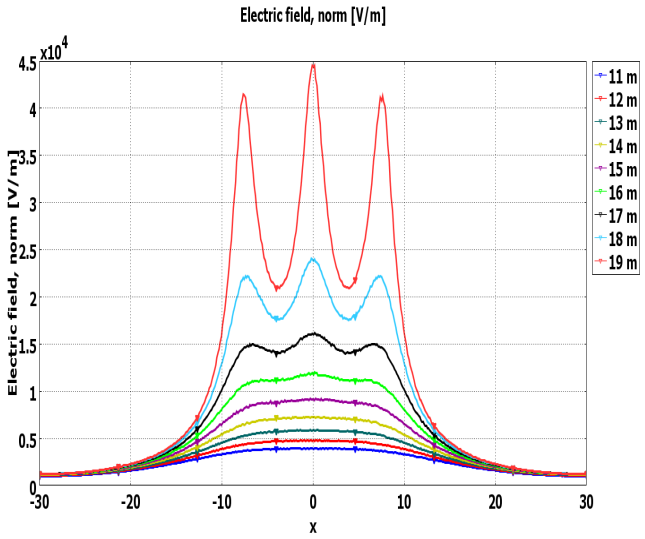

Fig. 5. Lateral profiles of electric field for the levels between 11 to19m.

Also, the electric field distribution up to the conductors levels has been studied .Fig.6. shows the profile of the electric field at levels between 21 to 30 m.

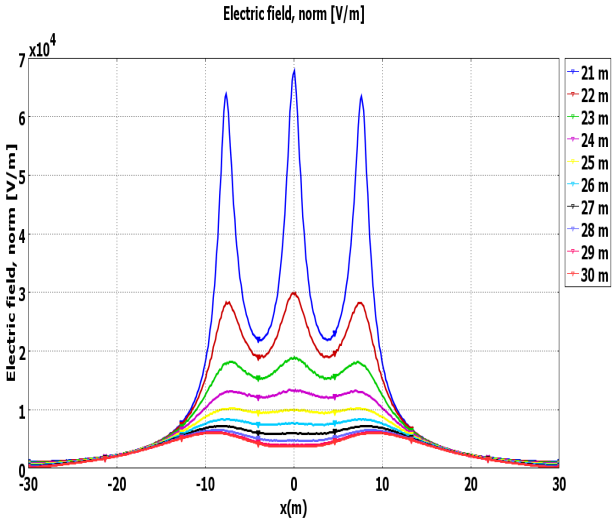

Fig. 5. Lateral profiles of electric field for the levels between 21 to30m.

B. *Behavior of magnetic field*

The same strategy is used to evaluate the magnetic field in the vicinity of high voltage lines. The current circulates in the conductors of the power line is equal to 270 A.

Fig.6 shows the lateral magnetic field profiles at 0m,1.5m and 1.8 m above ground.

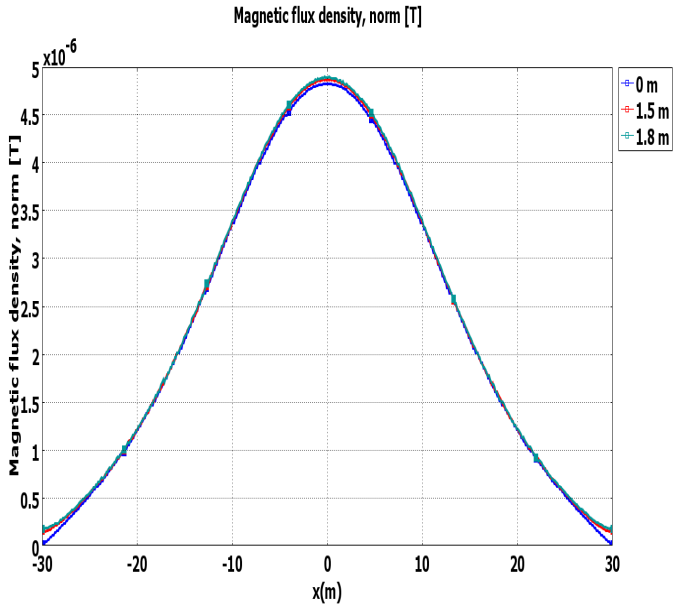

Fig. 6. Lateral profiles of magnetic field for levels (0m-1.5m-1.8m)

Fig. 7,Fig.8 and Fig.9 show the magnetic field distribution for the other levels.

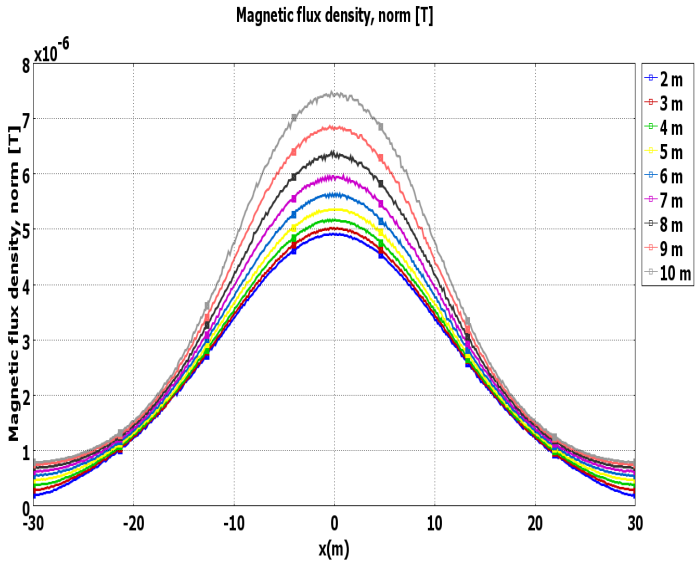

Fig. 7. Lateral profiles of magnetic field for levels between 2 to10m .

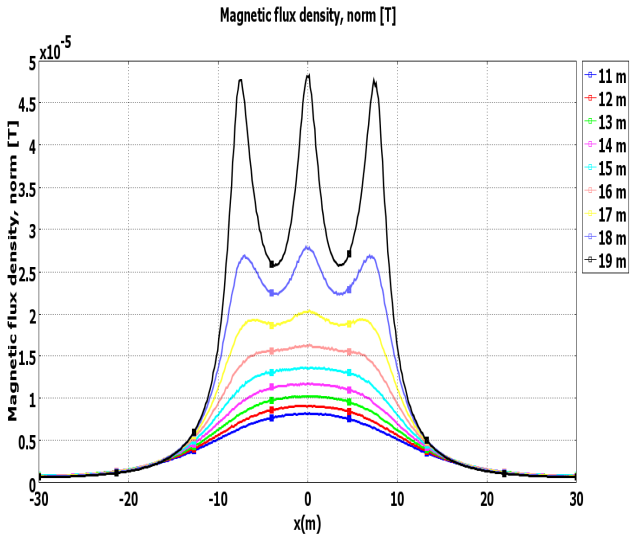

Fig. 8. Lateral profiles of magnetic field for levels between 11 to19m .

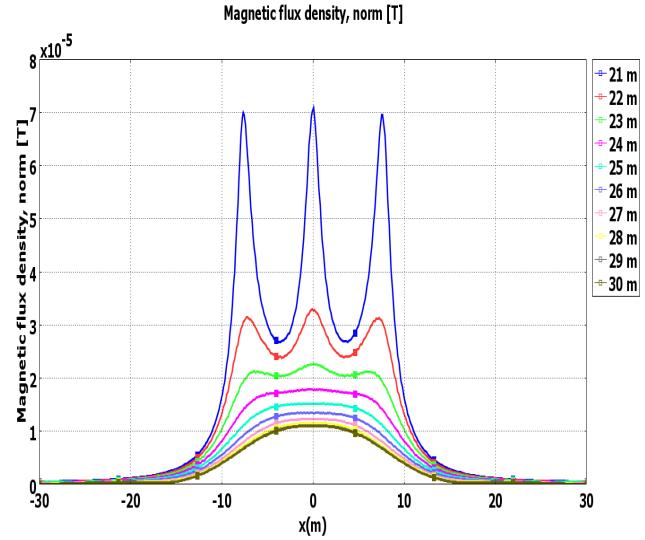

Fig. 9. Lateral profiles of magnetic field for levels between 21to30m .

V. DISCUSSION AND CONCLUSION

This paper studies numerically the electric and magnetic fields distributions of overhead 220 KV power lines operating at a frequency of 50 Hz of the transmission network for overhead power lines. A detailed review of the different issues related to the calculation of electric and magnetic fields has been presented. The finite element analysis using COMSOL MULTIPHYSICS software is a numerical method that can be recommended for the analysis of the electromagnetic field at any location near high voltage lines . The intensities of the electric and magnetic field close to land are well below the limits set by the International Commission on Non Ionizing Radiation Protection (ICNIRP) field guidelines (5KV/m for the electric field and 100 µT for the magnetic field).

This work could be extended to analyze the effects of obstacles, humans, vehicles and fences on the electric and magnetic fields values.

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