MAGNETIC FIELD INDUCED BY OVERHEAD POWER TRANSMISSION LINES IN ALGERIAN NETWOORK

Yamina Belkhiri* - Cherif Fetha**
*Electrical Department, Faculty of Technology, Batna University, Batna 05000, Algeria
Email:belkhiriyamina@yahoo.com
**Electrical Department, Faculty of Technology, Batna University, Batna 05000, Algeria
Email:cheriffetha@gmail.com

Abstract: This paper present simulation by COMSOL software of magnetic field at the extremely low frequency (ELF) generated in the vicinity of high voltage (HV) 60kV and extremely high voltage (EHV) 220kV and 400 kV power transmission lines in Algerian national electricity power transmission system. The influence of current loading at the magnetic field as well as the variation of towers configuration and the variation of conductors sections are treated. The experimental measurements of magnetic field near overhead power transmission lines are done by CHAUVIN ARNOUX (C.A 40 gaussmeter). The results of simulation and measurements are compared to safety limits exposures given by international commission on Non Ionizing Radiation protection (ICNIRP).

Keywords: Magnetic field, Magnetic induction, Algerian electricity power Transmission System, Load Current, Conductor section.

1 INTRODUCTION

Considerable researches focused on the evaluation of magnetic field at Extremly low frequency (ELF) near overhead power transmission lines (OHTLs) to insure the safety for human health. According to international commission for Non ionizing radiation protection (ICNIRP) the safety limits exposure to magnetic field in extremely low frequency is 100µT for people and 500µT for professional workers [1]. it will be very interesting for Algerian people to know about the level of magnetic field induced by extremely high voltage (EHV) power transmission lines[2][3] 400kV with consistency 2900 km which are recently introduced and used in Algerian national electricity power transmission system and compare the results with magnetic field values generated by classical and usual power transmission lines 60kV with consistency 9500 km and 220kV with consistency 13500 km in Algerian national electricity network [4][5].

Numerical computation is made for several towers configurations, horizontal, vertical, and delta, for various voltage levels such 60kV and 220kV at 50Hz with one and two conductors per phase. The magnetic field was simulated at 2m above the ground. Therefore, in this work we will try to evaluate the influence of different configurations, load current and the variation of conductor's sections on the magnetic induction B, we considered the most used conductor's in Algerian network like 570mm² ALMELEC (AAAC) and 288mm² ALU/ACIER(ACSR). Simple circuit with two conductor bundle 400kV line interconnecting the East to the North of Algeria from 400/220 kV substations SKIKDA, RAMDANE DJAMAL, OUED EL ATHMANIA, SALEH BEY, BIR GH'BALOU, SI MUSTAPHA and EL AFFROUN was treated and for the level 60kV and 220 kV we have considered the interconnecting lines between HASSI AMEUR 220/60 kV substation and PETIT LAC 220/60/30 kV substation located in Oran city in the west of Algeria [4][5]. We have used Suparul Cable Height Meter for measurement [6].

For this work the magnetostatic model of COMSOL software was used to simulate and calculate the magnetic field at the vicinity of HV and EHV power transmission lines of Algerian transmission system at 2 m height above the ground with using a real value of current measured in each substation at different moment of the day. The calculated results of magnetic field are compared with those obtained by practical measurements using C.A 40 Gaussmeter device [7].

2 MAGNETIC FIELD GENERATED BY POWER TRANSMISSION LINES

The phases conductors are assimilated at infinite length conductors which are crossed by current, the close loops of magnetic field are created around. The magnetic induction B caused by the current I flowing through the conductor with infinite length can be calculated by using Ampere law (1) [8].

$$H = \frac{I}{2\pi r} \qquad (1)$$

Magnetic induction **B** is related with magnetic field by:

$$B = \mu H \qquad (2)$$

Where: $\mu = \mu_0\mu r$
μ_r: permeability relative ($\mu_r = 1$)
μ_0: permeability of the free space ($\mu_0 = 4\pi\, 10^{-7}$ H/m)

so

$$B = \frac{\mu_0 I}{2\pi r} \qquad (3)$$

Where: I is the line current and r the distance between the conductor and the considerate point P [9].

3 ELECTROMAGNETIC MODELS

The electromagnetic phenomenon are whole described by J.C Maxwell laws, according to devices studies certain phenomenon are negligees, the laws uncoupled so the simple models are obtained [10].

For this work we have chosen magnetostatic model where the current source was quasi-static, magnetic induction was created by induced currents. Knowing the potential vector A gives the knowledge of all the physics parameters where:

$$ROT\,H = J \qquad (5)$$

$$B = ROT\,A \qquad (6)$$

2D spatial evolution of electromagnetic phenomenon was given by magnetostatic law:

$$ROT\left[1/\mu\, ROT\,A\right] \qquad (7)$$

Equation (7) describes the magnetostatic comportment of straight conductor crossed by current [8][11]. Therefore, in this work we will try to study magnetic field overhead power transmission lines for different towers configurations, the influence of load current I and the variation of sections conductors on the values of magnetic induction **B** [9] [10].

4 GEOMETRIC MODELS

The towers geometries of single circuit 60 kV, 220kV with one conductor per phase and two conductors per phase are those represented in figures (1) and (2). The 400kV line has twin bundle conductors per phase interconnecting the East and West of Algeria was represented in figure (3). Assuming that the over head phase's bundles is replaced with equivalent single conductors. For 400kV two cases are treated, the first case the phases conductors are at 16.40m from the ground, the second case the phase's conductors are at 50m from the ground.

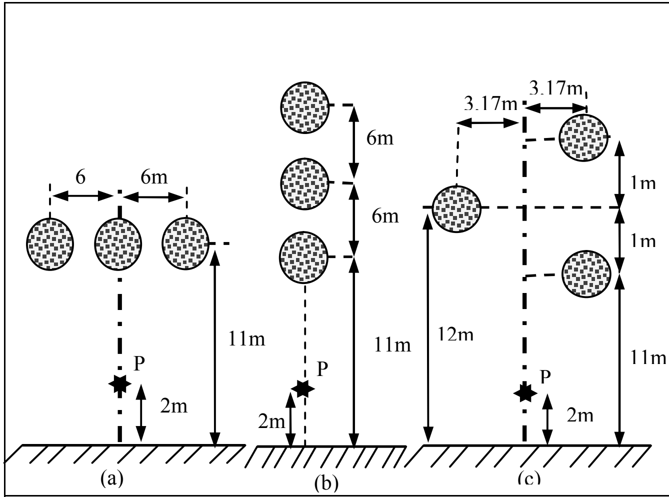

FIG.1.Different configuration for single circuit 60kV

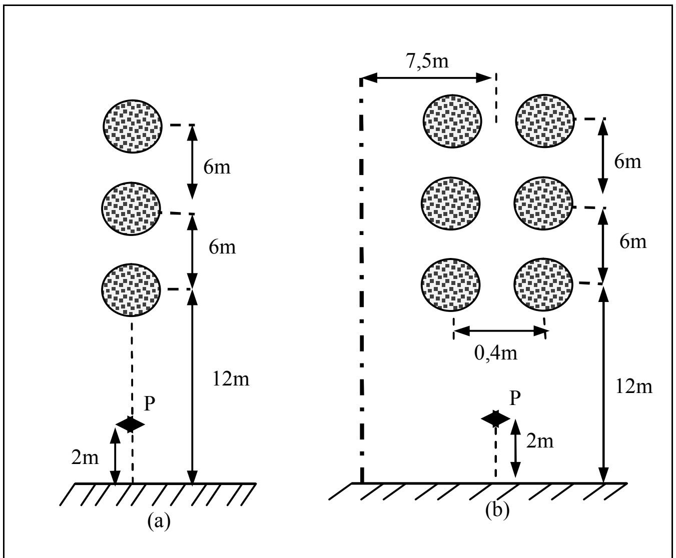

FIG.2.Different configuration for single circuit 220kV

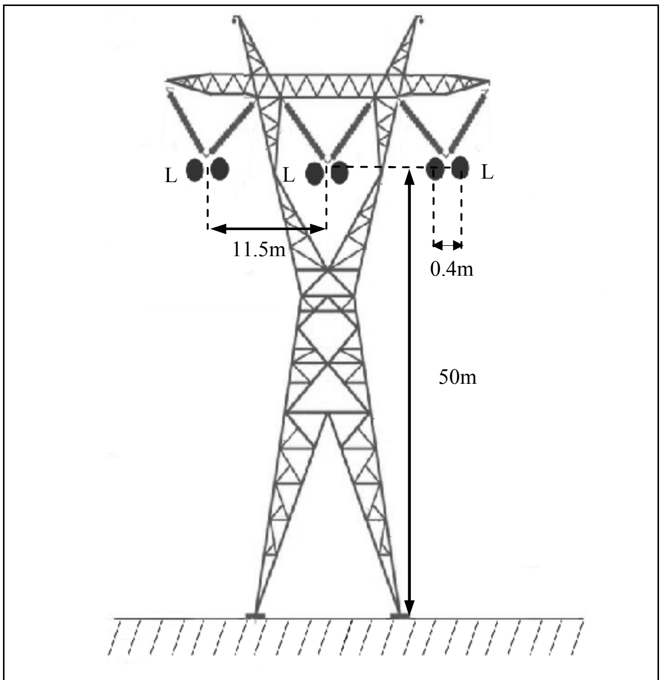

FIG.3.Tower line single circuit 400 kV

5 RESULTS AND DISCUSSIONS

5.1 Magnetic induction at 2m above the ground at various load current and various configurations for 60kV single circuit line

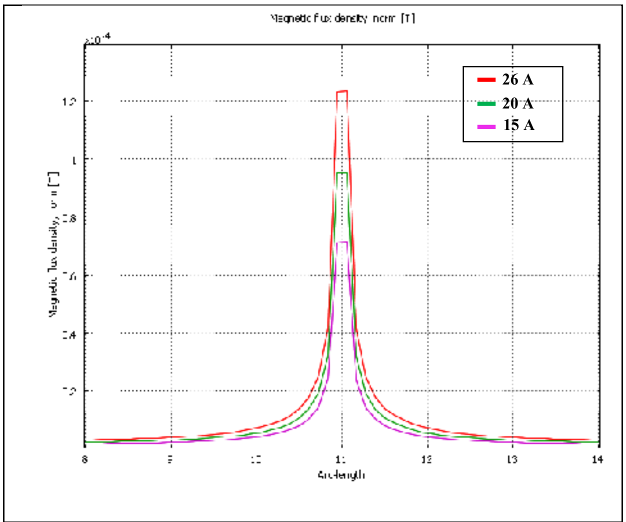

Fig.4.Magnetic induction for 60kV – 50 Hz Horizontal single circuit line

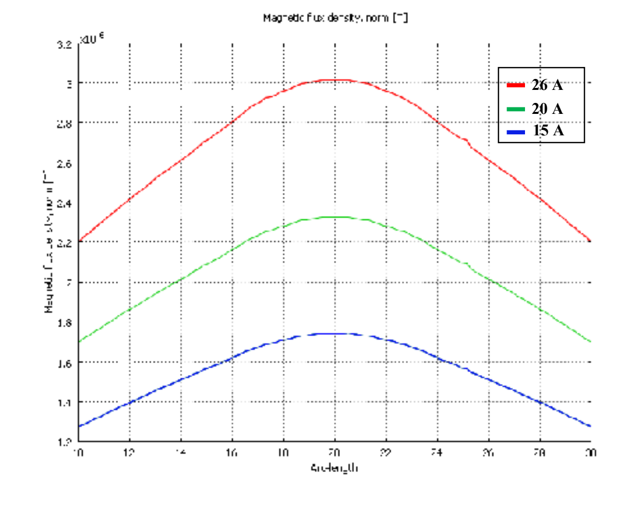

Fig.5.Magnetic induction for 60kV – 50 Hz Vertical single circuit line

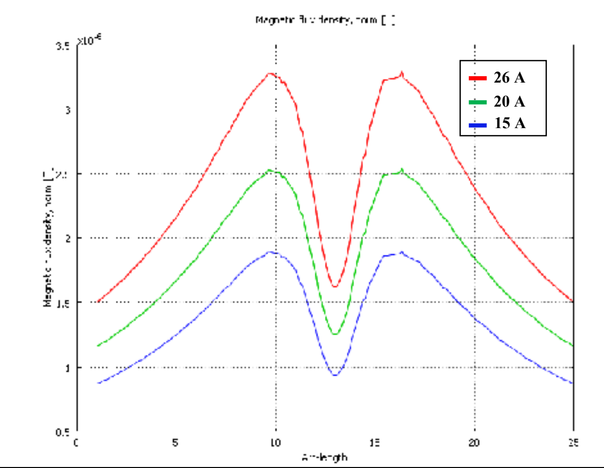

Fig.6.Magnetic induction for 60kV – 50 Hz Triangular single circuit line

Table1. Magnetic field for different configurations and various levels load currents at 2m above the ground for 60kV – 50 Hz single circuit

Configurations	Load current I[A]	Magnetic induction calculated B[μT]	Magnetic induction measured B[μT]
Horizontal	26	1.56	1.65
	20	1.20	1.27
	15	0.90	0.96
Triangular	26	1.62	1.73
	20	1.26	1.35
	15	0.94	1.02
Vertical	26	3.00	3.11
	20	2.32	2.42
	15	1.74	1.83

Figures 4, 5 and 6 show that magnetic induction for 60kV line increases with a high value of current loading. Table (1) shows the magnetic induction comparison for 60kV single circuit line at 2m above the ground with horizontal, vertical and triangular configurations. It is observed that the magnetic induction generated by vertical configuration is higher than the magnetic induction generated by horizontal and triangular configurations. Also magnetic induction generated by delta configuration is higher than the magnetic induction generated by horizontal configuration.

5.2 Magnetic induction at 2m above the ground at various load current and different conductor's section for 220kV single circuit line

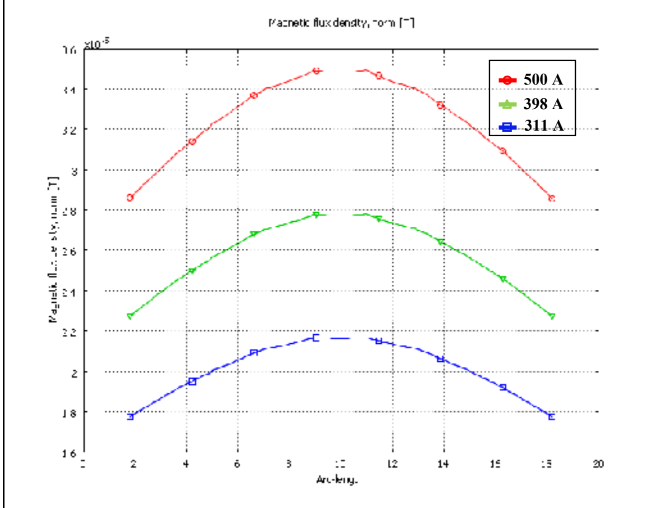

Fig.7.Magnetic induction with conductor section S = 570mm² for 220kV-50Hz vertical single circuit line

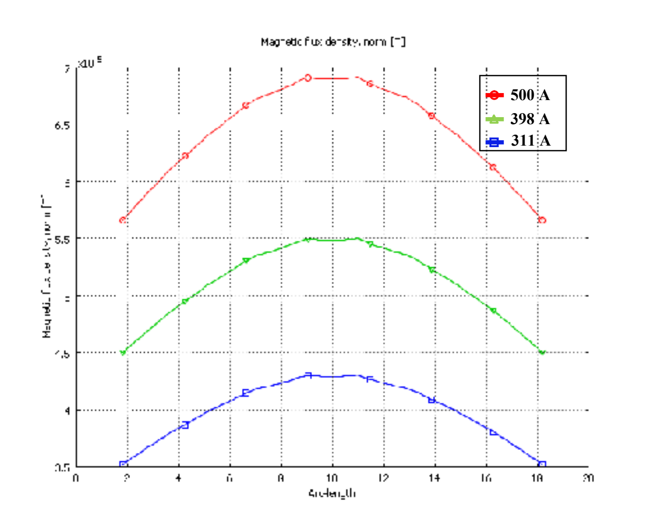

Fig.8.Magnetic induction with conductor section S = 288mm² for 220kV-50Hz vertical single circuit line

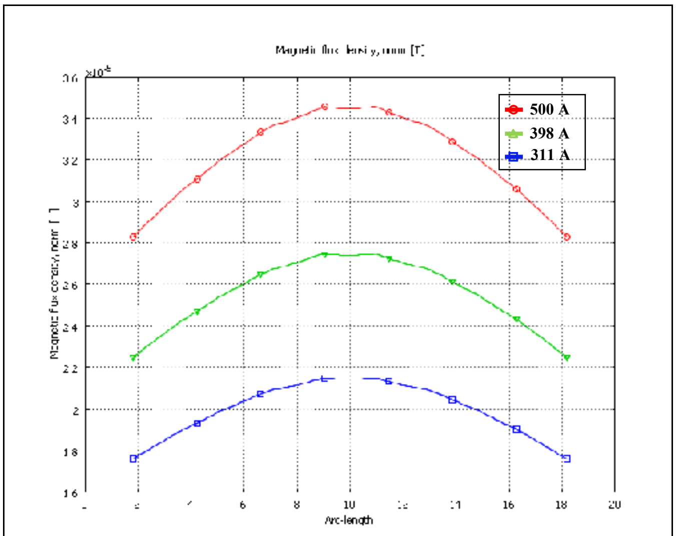

Fig.9.Magnetic induction with conductor section S = 2x288mm² for 220kV-50Hz vertical single circuit line

Table 2. Magnetic induction for different conductors sections and various load current		
Sections of conductors S [mm2]	Load current I[A]	Magnetic induction B[µT]
2x288	500	34.46
	398	27.40
	311	21.44
570	500	34.82
	398	27.72
	311	21.64
288	500	68.94
	398	54.84
	311	42.89

Figure (7) shows that the magnetic induction increases as the load current levels increase for 220kVsingle line. Table (2) shows the magnetic induction comparison at 2m above the ground for 220kV single circuit line with different sections of conductors. It is observed that the magnetic induction generated by 220kV line with twin bundle conductors per phase 2x288 mm^2 is lower than the magnetic induction generated by 220kV single circuit line with one conductor per phase section 288 mm^2 but it's similar with 570 mm^2 sections because the current density J decreases with increasing conductors section at the same load current. It is clearly observed for 220kV line that the values of magnetic induction not exceed 100µT limit exposure given by (ICNIRP) [1].

5.3 Magnetic induction at 2m above the ground for various current loading for 400kV single circuit OUED EL ATHMANIA- SALEH BEY Line

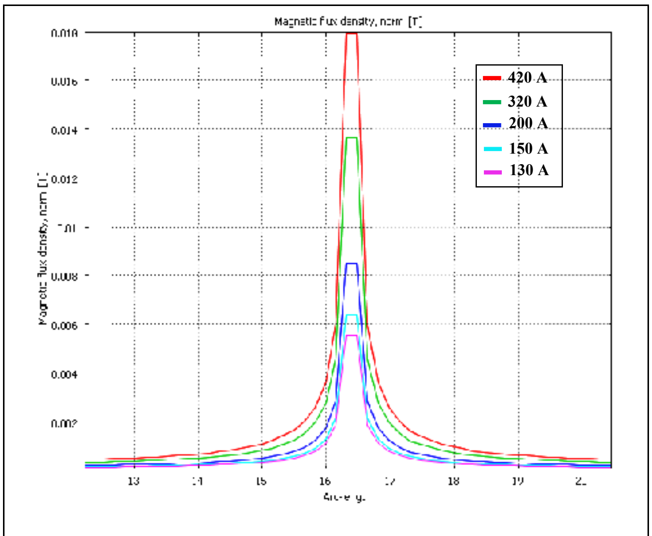

Fig.10.Magnetic induction for 400kV-50Hz single circuit line 16.40m height between ground and conductor

Table 3. Magnetic induction for different levels of load current and 16.40m height between ground and 400kV line		
Load current I[A]	Magnetic induction calculated B[µT]	Magnetic induction measured B[µT]
420	275.3	277.1
320	209.46	211.2
200	131	132.6
150	98	99.5
130	85.28	86.6

Fig.11.magnetic induction measurement for 400kV line

Fig.12. Height measurement between ground and conductor

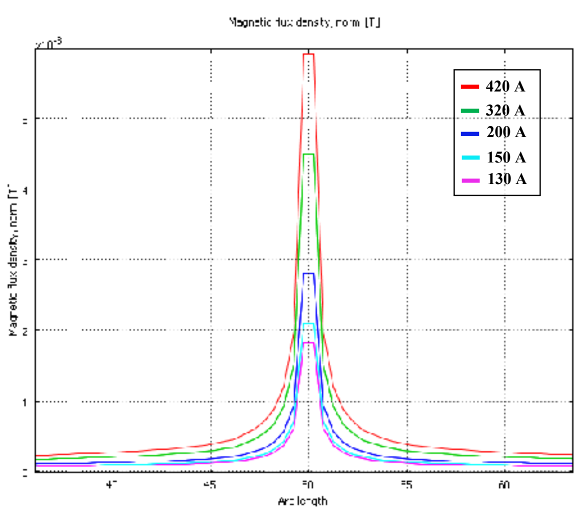

Fig.13.Magnetic induction for 400kV-50Hz single circuit line 50m height between ground and conductor

Table 4. Magnetic induction for different levels of load current and 50m height between ground and 400kV line

Load current I[A]	Magnetic induction calculated B[µT]	Magnetic induction measured B[µT]
420	86.37	87.65
320	65.71	66.95
200	41.07	42.1
150	30.74	31.75
130	26.75	27.75

The magnetic induction of figure(10) and figure (13) have a high values for increasing load currents, also Table (3) show clearly safety limit of 100µT was exceed for currents equal 150A ,this for 16.40m height between ground and conductor, but fortunately this type of towers cross agricultural and hill areas, so population wasn't touched by magnetic field however, Table (4) show clearly that the safety limit of 100µT is not exceed for various load current, especially for high-tech current 420A. More the line is close to the ground more is the magnetic flux density because magnetic field decreases as we go away from the source of its creation which is the circulating current in the conductor.

6 CONCLUSION

This paper demonstrates the effectiveness of using the magnetostatic modules of the COMSOL software for calculating the magnetic fields generated in the vicinity of overhead power transmission lines. Several cases were used in such validation and the generated results were compared with those measured by using CA 40 gaussmeter.

The results using COMSOL are produced in very good agreement with their corresponding results measured.

So at normal operating condition, the magnetic flux density varies with the distance from the center phase for different percentage of load current and conductor's sections, also , the decrease in the load capacity decreases the magnetic flux density. More than the magnetic flux density has its maximum value when the clearance between the conductors and the ground level has its minimum value. But directly under tower height, magnetic flux density has its minimum value due to the maximum clearance between the conductors and the ground level.

In this work it is observed that magnetic field induced by 400kV power transmission lines are very important than those produced by 220 and 60 kV lines, this is not according to the voltage values but because the 400 kV lines interconnected the most important power plant in Algerian grid transmitted a considerable load current comparing to the 220 and 60 kV lines.

Generally for people standing under power transmission lines, the safety limits for magnetic flux depends on the height, spacing of the overhead conductors and load current values.

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