International Journal of Engineering and Applied Sciences (IJEAS)
ISSN: 2394-3661, Volume-7, Issue-5, May 2020

Magnetic field calculation of overhead transmission lines

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Abstract: **The integration of Vietnam's economy in recent years has resulted in increasing demand of electricity, with the establishment of many ultra-high-voltage transmission lines leading to various load centers. Therefore, many of the effects of these lines on inhabitants need to be considered. The negative impacts of industrial frequency of magnet fields on humans and the environment are matters of concern for scientists as well as for domestic and international organizations. For this reason, the calculation of magnet fields of transmission lines, especially, super high voltage lines, is of paramount importance in the determination of magnet field influences. This paper presents the method for calculating magnet fields on electricity wire lines and some measures and solutions for the reduction of negative impacts of these fields will also be discussed.**

Index Terms: **Magnetic field of overhead transmission lines, EMFACDC software, Magnetic Field.**

I. Introduction

Together with the development of Science and Technology increasing, electricity is playing the important role in almost all economic sectors, the increase in demand of electricity consumption determines the social development and improves the life in a area, a country. Therefore, electrical systems are developed both in large-scale and in technology. Nowadays a great number of electricity systems established within national or international scale, and developed widely high-voltage and ultra-high-voltage transmission lines to carry out the communication and transmission of the power. Over the years, together with the development of economy, the demand of electricity in Vietnam has been considerable high, wherefore the 220kV and 500kV transmission lines have been developed. With the promulgation of Decree 106/2005/NĐ-CP on August 17th, 2005 allowing the citizens to live under the passage-ways where the lines' voltage is lower than 220kV. This article is to expose a calculation method H for the mentioned transmission lines and not to recommend a method for limiting impacts of electrical field on the citizens living under the passage-ways where the high-voltage electrical system are presented [4].

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This research is funded by Thai Nguyen University of Technology, Vietnam

II. Procedure for Paper Submission

A. *Calculation method*

He is originated from the capacitance between the conductor-wires and the ground or on anothers [1]. The H calculation for the mentioned conductor-wire is not based on the reflective mirror methods for the conductor with the boundary conditions is votage between the lightning diverter and the ground results cero. The calculation programma is realized by the EMFACDC software.

Analysing the cross section of a neutral conductor-wire in perpendicular direction with the conductor-wire which is located abover the ground a distance h as in the figure 1.

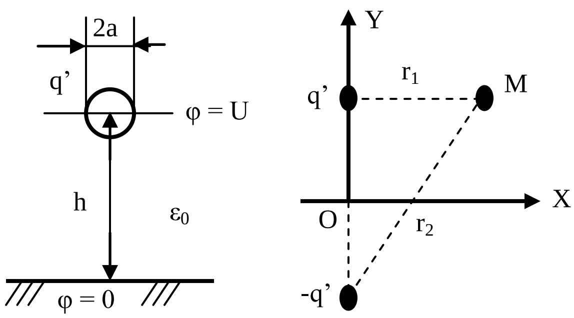


Figure 1. Structure scheme of the reflective mirror methods for the conductor

The conductivity of conductor is expressed in complex form as following:

$$\underline{\sigma} = \sigma + j\omega\varepsilon \quad \text{[S/m]} \tag{2.1}$$

According to the figure 1, the voltage in the point M is determined by the following expression:

$$\varphi = \frac{q'}{2\pi\varepsilon}.\ln\frac{r_2}{r_1} \quad \text{[V]} \tag{2.2}$$

Given $r_1 = a$, $\varphi = U$ we obtain:

$$\varphi = U = \frac{q'}{2\pi\varepsilon}.\ln\frac{2h+a}{a} \quad \text{[V]} \tag{2.3}$$

Deducing:

$$q' = \frac{U2\pi\varepsilon}{\ln(\frac{2h+a}{a})} \quad \text{[C]} \tag{2.4}$$

Substituting (2.4) in (2.2), we obtain:

$$\varphi = \frac{U}{\ln(\frac{2h+a}{a})}.\ln\frac{r_2}{r_1} \quad \text{[V]} \tag{2.5}$$

Mathematical model for E in space (r, θ, z) boudering the conductor is written as below:

$$\vec{E} = E.\hat{z}, E_r = 0, E(\theta) = 0, E = E(r) \qquad (2.6)$$

According to the wave equation of *Helholtz*:

$$\frac{1}{r}\frac{d}{dr}\left(r\frac{dE}{dr}\right) + k^2E = j\frac{\omega\mu I}{2\pi r}\delta(r) \qquad (2.7)$$

When r $\rightarrow\ \infty$, the ecuation (2.7) becomes:

$$\frac{\partial E}{\partial r} + E\left(j + \frac{1}{2kr}\right) = 0, r \rightarrow \infty \qquad (2.8)$$

Resolve (2.8) we obtain the solution:

$$E = CH_0^{(2)}(kr) \quad [\text{kV/m}] \qquad (2.9)$$

Where:

$$H_0^{(2)}(kr) = J_0(kr) - jN_0(kr) \qquad (2.10)$$

With:

$H_0^{(2)}(kr)$: Second order differential of the wave function.

$J_0(kr)$: Real part of the wave function.

$N_0(kr)$: Imaginary part of the wave function.

C is determined under the condition when k $\rightarrow$ 0

$$H = j\frac{kC}{\omega\mu}H_1^{(2)}(kr); \lim_{\omega\rightarrow 0} H = \frac{I}{2\pi r} \qquad (2.11)$$

Where: H Magnetic field intensity I generated.

B. Simulation of calculation

Boundary conditions applied here are votage between the lightning diverter and the ground results cero. Assume the load in balance. Conductores used for the simulation are aluminium conductor steel-reinforced (ACSR) which have characteristics as following: conductivity (σ) = $0{,}8\times10^{7}$ S/m, relative magnetic permeability (μ_r) = 300 H/m, and relative dielectric constant (ε_r) = 3,5 F/m [3]. Taking in accunt the relative dielectric constant of vacua (ε_0) = $8{,}85.10^{-12}$ F/m and relative magnetic permeability of vacua (μ_0) = $4\pi.10^{-7}$ H/m. Grid frequency f = 50 Hz.

Proceedures of resolving the problem

Step 1: Buil the structure of the reflective mirror methods for the conductor

Step 2: Determine the boundary conditions of the problem.

Step 3: Calculate the constants of algebraic equations.

Step 4: Resolve the algebraic equations.

Step 5: Exploit the results.

Simulation results

Factores used for the simulation are given in the figures 2, 3, 8, 9, 14 and 15.

Simulation and calculation results are showed in the figures 4, 5, 6, 7, 10, 11, 12, 13, 16, 17, 18 and 19.

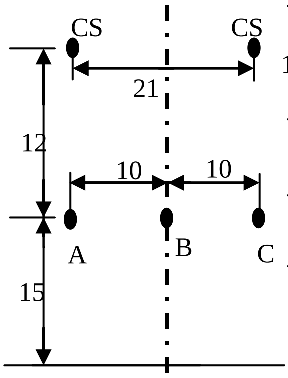


Figure 2. Size of the 500kV transmission line – 1 circuit at the maximum deflection (m)

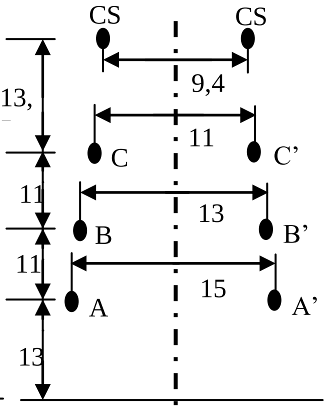


Figure 3. Size of the 500kV transmission line - 2 circuits at the maximum deflection (m)

Simulation and calculation results:

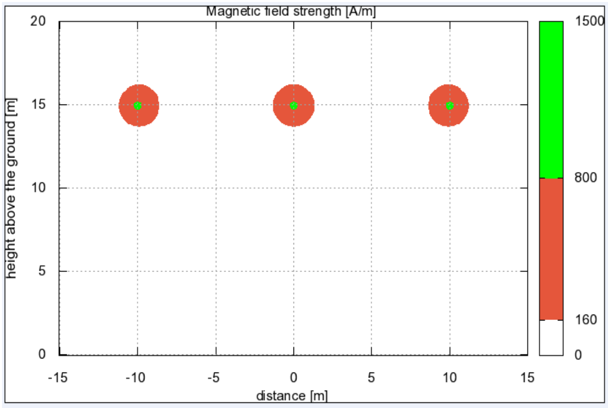


Figure 4. Distribution H of the 500kV transmission line - 1 circuit at the cross section

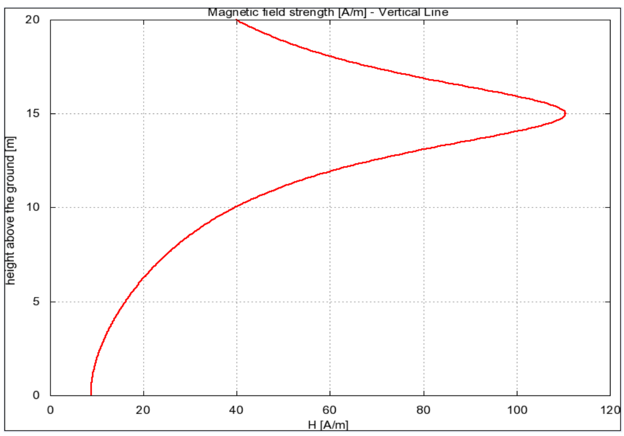


Figure 5. H of the 500kV transmission line - 1 circuit

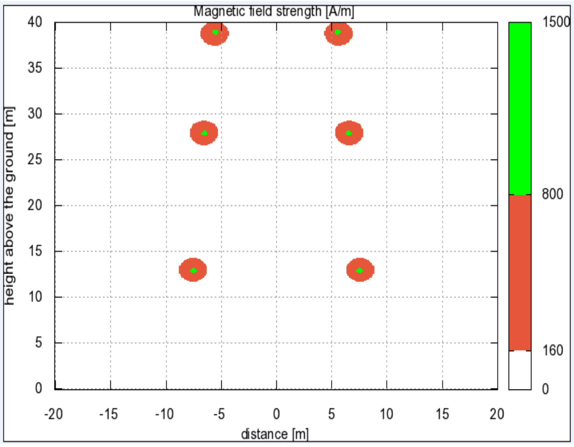


Figure 6. Distribution H of the 500kV transmission line - 2 circuits at the cross section

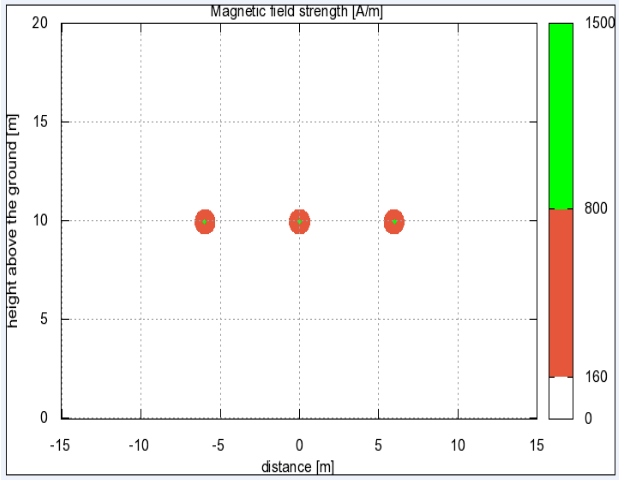


Figure 10. Distribution H of the 220kV transmission line - 1 circuit at the cross section

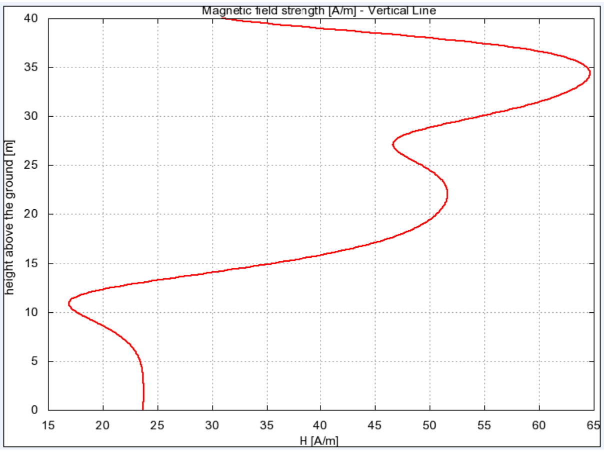


Figure 7. H of the 500kV transmission line - 2 circuits

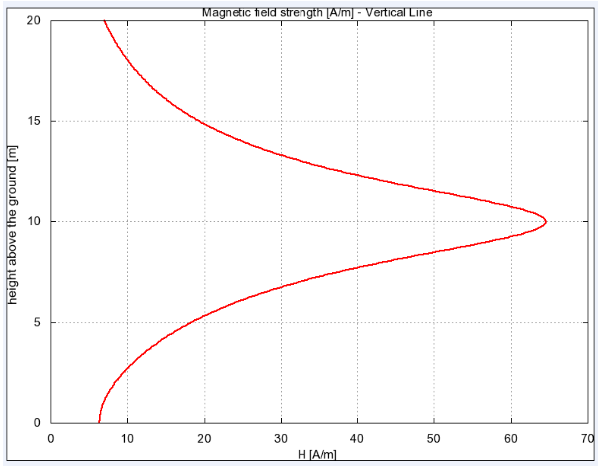


Figure 11. H of the 220kV transmission line - 1 circuit

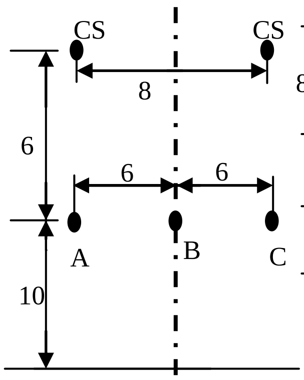


Figure 8. Size of the 220kV transmission line – 1 circuit at the maximum deflection (m)

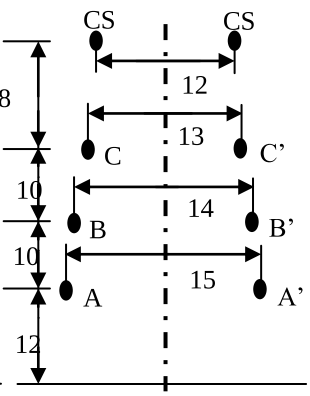


Figure 9. Size of the 220kV transmission line – 2 circuits at the maximum deflection (m)

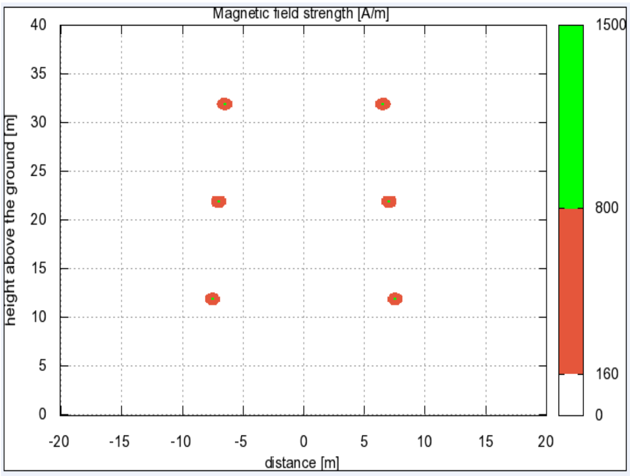


Figure 12. Distribution H of the 220kV transmission line - 2 circuits at the cross section

Simulation and calculation results:

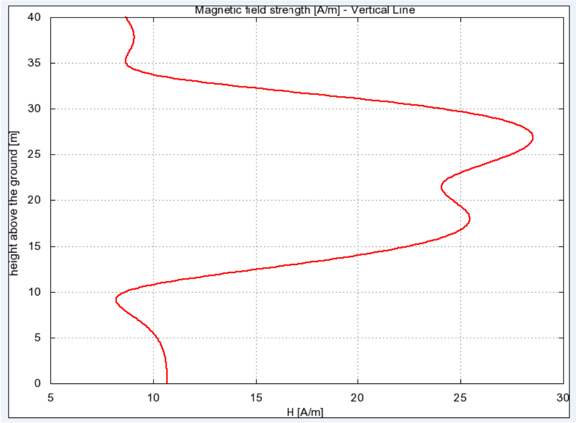


Figure 13. H of the 220kV transmission line - 2 circuits

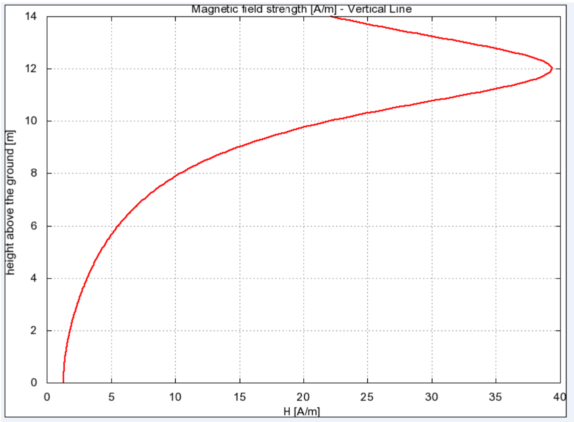
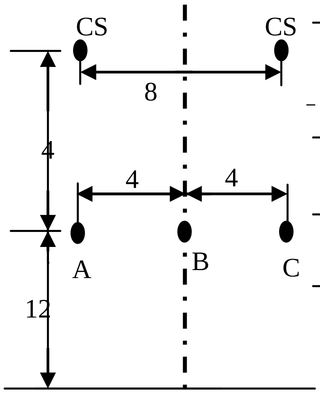


Figure 17. H of the 110kV transmission line - 1 circuit



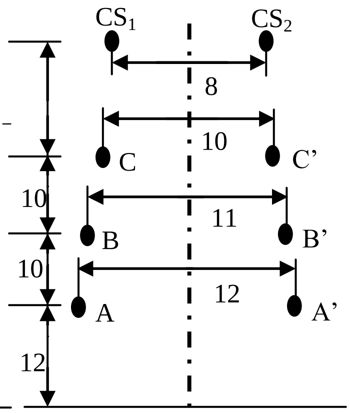


Figure 14. Size of the 110kV transmission line – 1 circuit at the maximum deflection (m)

Figure 15. Size of the 110kV transmission line – 2 circuits at the maximum deflection (m)

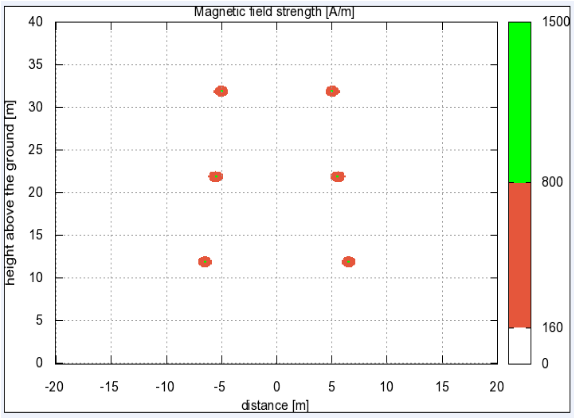


Figure 18. Distribution H of the 110kV transmission line - 2 circuits at the cross section

Simulation and calculation results:

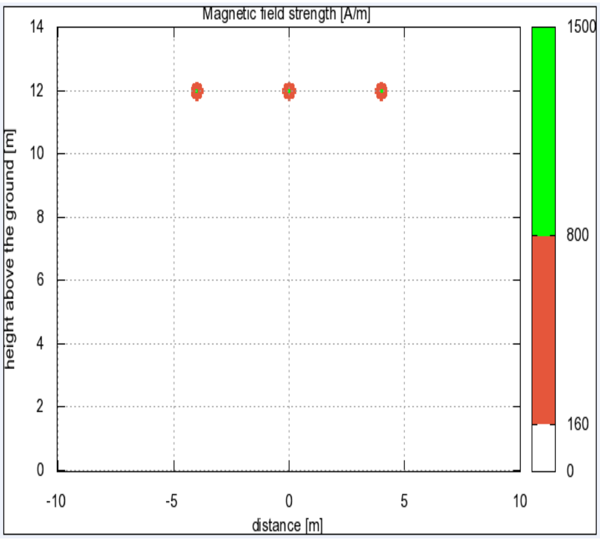


Figure 16. Distribution H of the 110kV transmission line - 1 circuit at the cross section

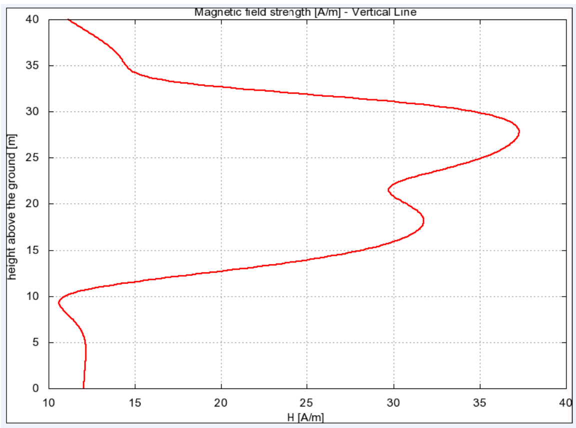


Figure 19. H of the 110kV transmission line - 2 circuits

III. CONCLUSION

This article was investigated in the distribution of H and surrounding the conductor-wire in symmetrical load codition. The computer simulations was carried out by the application of the on the reflective mirror methods for the conductor combined with the EMFACDC software and the results demonstrated that H of both cases of simple circuit and dual circuits of the conductor-wires 500 kV, 220 kV, 110 kV at the height of 2 m from the ground where was assume as human workplace under the lines. According to the standards established in Vietnam [2] and the calculation results showed that people will be assured safety with the height H < 160 A/m.

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