The Influence of Suspension Towers on the Directional Energy Flux Density along a Transmission Route

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Abstract The paper deals with the influence of suspension towers on the directional energy flux density (Poynting vector) along a transmission route. The computation of an electromagnetic field along a power overhead line is performed by means of an integral method in the 3D arrangement.

Keywords Poynting vector, power overhead line, suspension towers, integral equations.

I. INTRODUCTION

From a general point of view, the directional energy flux density (Poynting vector) along a transmission route has the same direction as a power overhead line. However, the Poynting vector around a suspension tower is influenced by the tower.

II. FORMULATION OF THE PROBLEM

The investigated case is depicted in Fig. 1, showing the suspension tower with 2 x 110 kV overhead line and the rectangular area of dimensions 21 x 11 m selected for the computation of the Poynting vector. This area is coplanar to the ground plane at the height of 1.8 m above the ground. The maximum possible value of the current passing through the phase conductors is 1240 A.

![Fig. 1. Suspension tower and computation area](image)

III. MATHEMATICAL MODEL

This time-dependent problem was solved threedimensionally in the Cartesian coordinate system x, y, z. The magnetic field strength \( B \) produced by the line at point \( Q \) is determined by means of an integral equation (Biot-Savart law)

\[
B(Q) = \frac{\mu_0 I}{4\pi} \int_{\Omega} \frac{d\tau \times r_{PQ}}{r_{PQ}^3} d\tau
\]

where \( \mu_0 \) is the permeability of air, \( d\tau \) is an element of the length of the conductor at general point \( P \), and \( r_{PQ} \) is a radius vector that begins at point \( P \) and ends at point \( Q \). The symbol \( I \) denotes the current passing through the conductor. The electric field strength \( E \) is determined by means of the integral equation

\[
E(Q) = \frac{1}{4\pi\varepsilon_0} \int_{S} \frac{\sigma(P) - r_{PQ}^3}{r_{PQ}^3} dS
\]

where \( \sigma \) is the surface charge density.

The distribution of the Poynting vector \( N \) was calculated using the formula

\[
N = E \times (B / \mu_0)
\]

IV. RESULTS OBTAINED

Figure 2 demonstrates the Poynting vector in the selected rectangular area. The maximum value of the Poynting vector 24861 W/m² is only valid at the individual nodes of the grid in which the set distance between two adjacent nodes was 0.25 m.

![Fig. 2. Poynting vector in the selected rectangular area for the time \( t = 0 \)](image)

V. CONCLUSION

The aim of this paper was to calculate the Poynting vector along a transmission route around a suspension tower. The results clearly show that suspension towers significantly affect the directional energy flux density.

VI. ACKNOWLEDGEMENTS

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VII. REFERENCES
