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The Electromagnetic Field Around a High Voltage 400 KV Electrical Overhead Lines and the Influence on the Biological Systems

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Abstract: In this paper the analytical calculus and the experimental measurements of the electric and magnetic field around a high voltage 400KV electrical overhead lines has been analyzed. There have been analyzed the possible influences of the electromagnetic field on the health of the human beings. The calculus has been done using the MatLab medium, the experimental measurements of the electric strength have been done using a spherical dipole.

Keywords: Electromagnetic field, high voltage, human beings, MATLAB script.

1 Introduction

The development of the electromagnetic devices, very useful in our daily life, has also some useless effects, which affect the environment and in some cases produce serious unbalances. The present paper refers to these aspects, trying to systematize the knowledge for evaluation of the electromagnetic field around the three-phase conductors. Knowing the values of the electromagnetic field around a three-phase electrical overhead line is important for the protection of the voltage substation workers.

The calculus of the electromagnetic field around the high voltage electrical overhead lines has been made using the MatLab medium. The steady state of the electrical lines has been considered during the calculation of the electric and magnetic field.

A device based on a spherical dipole for measuring the electrical field has been presented in [1]. The presence of the device in an electrical field has a less influence

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over the field distribution. The experimental measurements show that in electrical fields that exceed 500 V/m, the human presence at a distance greater then 1.5m does not affect the precision of the device. The experimental measurements in this paper have been made on the 400 KV electrical line Mintia-Arad.

2 The Electric Field Around a High Voltage Three-Phase Electrical Overhead line [2, 3]

The calculus of the potential V (against the earth) and the electrical strength E around a three- phase high voltage overhead electrical line with double circuit, Fig. 1, has been made using the "electrical imagine method". Using the "superposition principle" we obtained the values of the electromagnetic quantities in a current point around the line.

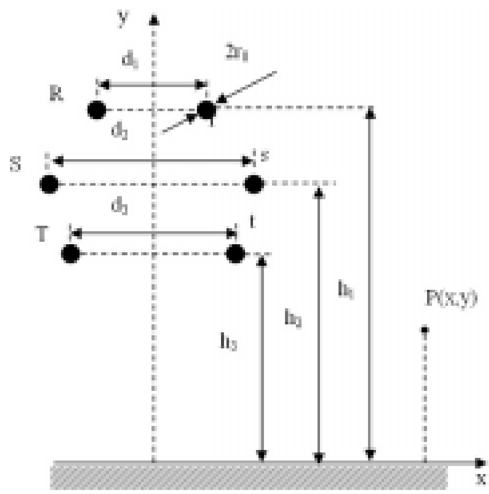

Fig. 1. The sketch of a high voltage three-phase electrical overhead line with double circuit.

For the evaluation of the potential V, has been used, [3, 4]:

$$V_{p_i} = \alpha \sum_{k=1}^{n} q_k \ln \frac{r'_{pki}}{r_{pki}} \tag{1}$$

and for the electric field strength in a current point, $P(x,y)$

$$E_{px_i} = \alpha \sum_{k=1}^{n} q_k x_{p_k} F_{pki} \tag{2}$$

$$E_{py_i} = \alpha \sum_{k=1}^{n} q_k y_{p_k} F_{pki} \tag{3}$$

We have denoted $\alpha = 1/(2\pi\varepsilon_0)$, with $\varepsilon_0 = 1/(4\pi 910^9)$ F/m and $F_{pki} = 1/r_{pku}^2 - 1/r_{pki}'^2$, where r_{pki} is the distance between the phase k and the current point P; r'_{pki} is the distance between the electrical image of the phase k and the current point P; n is the number of the phases that take influence over the electrical quantities that are calculated; qk is the electrical charge of the phase k, considered as a linear distribution.

Note that the electrical potential V and the electric field strength E depend on the electrical charges from the three-phase conductors and on the geometrical design of the pillars, and the lines.

Using the Maxwell equations for capacities, the linear distributed electrical charge on the phase conductors is

$$[U] = [p][q] \tag{4}$$

where $[U]$ is the phases potential matrix (towards the earth) and $[q]$ is the potential coefficients matrix in form

$$p_{ij} = \alpha \ln \frac{D'_{ij}}{D_{ij}} \qquad p_{ii} = \alpha \ln \frac{D'_{ii}}{r_{0i}} \tag{5}$$

with D_{ij} the distance between the conductors i and j; D'_{ij} the distance between the conductor i and the image of the conductor j (against the earth); r_{0i} the radius of the conductor i.

3 The Magnetic Field Calculation Around a 400 KV Three-Phase Electrical Line

In Cartesian coordinates (x,y,z), the three-phase current flows in the direction of z axes, are: (6)

The magnetic flux density components produced by the currents (6), are:

$$\underline{I}_R = I \qquad \underline{I}_S = Ie^{-j\frac{2\pi}{3}} \qquad \underline{I}_T = Ie^{j\frac{2\pi}{3}} \tag{6}$$

The magnetic flux density components produced by the curents (6) are

$$B_{px_i} = -\beta \sum_k \underline{I}_k \frac{y_{pki}}{r_{pki}^2} \tag{7}$$

$$B_{py_i} = \beta \sum_k \underline{I}_k \frac{x_{pki}}{r_{pki}^2} \tag{8}$$

and the magnetic flux density is

$$B_{pi} = \sqrt{B_{Px_i}^2 + B_{py_i}^2} \tag{9}$$

where $\beta = \mu_0/(2\pi)$ and $\mu_0 = 4\pi 10^{-7}$ H/m.

4 Numerical Evaluation

The calculus for the electric and magnetic field around a three-phase high voltage 400 KV overhead electrical line with double circuit has been made using the MatLab medium. Considering line pillars type Sn 400.272, we show below the initial dates used as program steps in numerical evaluation.

MATLAB Script

```
%Initial Data
>> h1=26; h2=16.25; h3=8;
>> d1=14; d2=22; d3=14;
>> r0=92.5*10^(-3);
>> L=10^4;
>> eps0=1./(4*pi*9*10^9);
>> miu0=4.*pi.*10.^-7;
>> f=50; ro=50;
>> omega=2.*pi.*f;
>> Rcp=550.*sqrt(ro./f);
%Phase voltage
>> U=zeros(6,1);
>> U(1,1)=230.94*10^3;
>> U(2,1)=( 230.94*10^3)*(-.5-i*sqrt(3)/2);
>> U(3,1)=( 230.94*10^3)*(-.5+i*sqrt(3)/2);
>> U(4,1)=U(1,1); U(5,1)=U(2,1); U(6,1)=U(3,1);
%The phases current flow
>> I1=200; I2=200.*(-.5-i*sqrt(3)/2);
>> I3=200.*(-.5+i*sqrt(3)/2);
>> I4=I1; I5=I2; I6=I3;
```

There results for the electrical potential V (against the earth), the electric field straight E, and the magnetic flux density B are presented in Fig.2, Fig.3 and Fig.4,[5].

5 Experimental Measurements

In order to verify the values of the electric field strength E obtained by numerical evaluation, we have determined the electrical field by experimental measurements

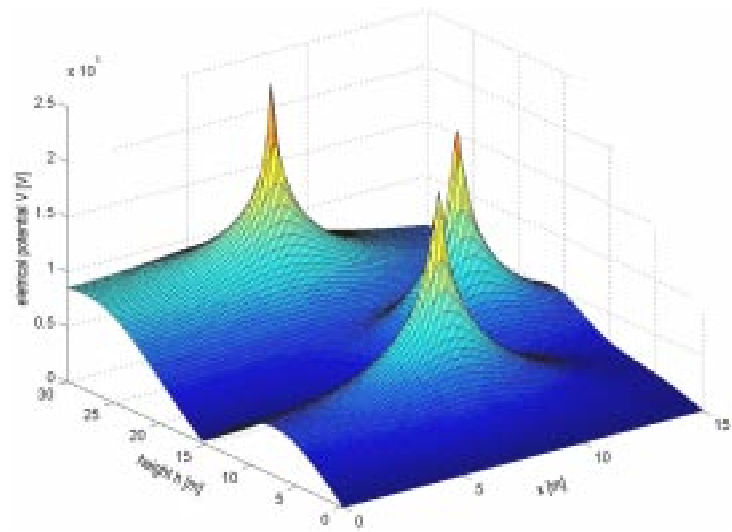

Fig. 2. The electrical potential around a three-phase high voltage overhead electrical line.

around a three-phase high voltage overhead electrical line, [5]. The experimental measurements have been done using an electrical device built in the Measurement Department of the ”Politehnica” University from Timisoara. In Table 1 we have presented the measured values of the electric field straight E, around the electrical

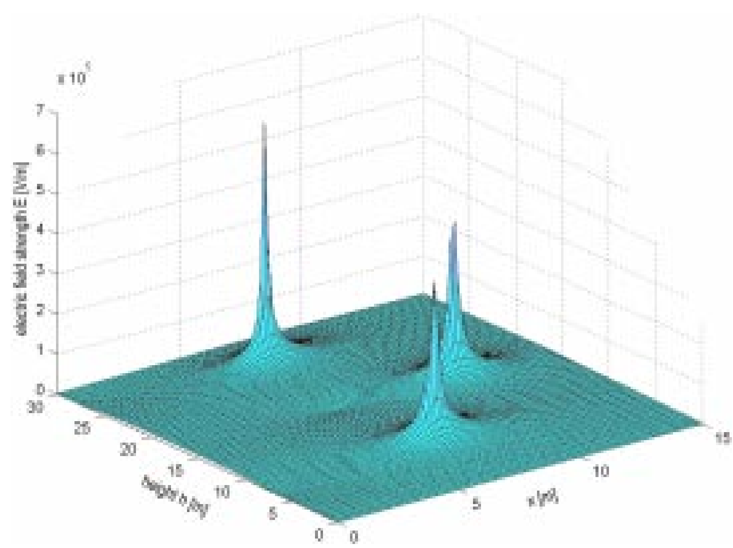

Fig. 3. The electrical field straight around a three-phase high voltage overhead electrical line.

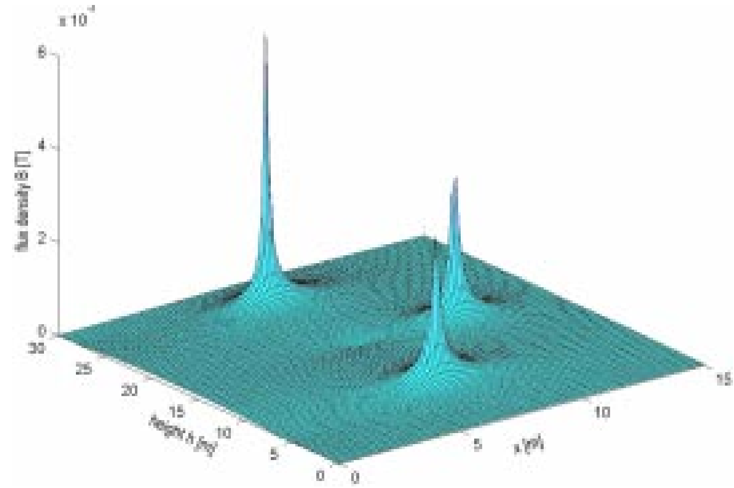

Fig. 4. The magnetic flux density around a three-phase high voltage overhead electrical line.

line from Mintia-Pestis voltage substation.

The measured values of the flux density vector B in different places around the electrical line from Mintia-Sibiu voltage substation are presented in Table 2. The current flow in line has been considered $I = 110$ A.

Table 1. The measured values of the flux density around electrical line.

[m]	E [KV/m]		
y_p/x_p	-11	0	11
24	26.08	20.35	-
25.5	34.85	-	35.92

Table 2. The measured values of the electrical field straight around electrical line

[m]	$B[\mu T]$		
y_p/x_p	-11	0	11
24	5.63	6.04	-
25.5	14.11	-	15.86

6 Conclusions

On the values of the electrical potential V and the electric field strength E around a 400 kV high voltage overhead line, it follows:

- the highest value of the potential (against the earth) and the electric field strength takes place in the neighborhood of the conductor S in the point ($x = 0$, $y = 20$ m); the point is placed on the pillar axes at a height of 20m, vhere $V = 40.35$ kV and $E = 20.36$ kV/m;
- around the conductor, the potential and the electric field strength decreases, so $U = 40.35$ kV and $E = 3.3$ kV/m;

- the highest value of the magnetic flux density takes place in the pillow axes around the conductor R. A value of $B = 138\ \mu$T, obtained on the pillow axes could be a dangerous value for the human body. The experimental measurement shows that the human presence around the lines modifies the electrical field distribution. The human insulation (against the earth) modifies the field value. Better insulation raises the value of the field. For a good insulation, the field could be 6-7 times greater in the case when human body is in contact with the ground. The electric field in the highest part of the human body could be reduced by using the protection equipment.

The highest values are mentioned, using the *General normes of work protection* from 1996, [2]:

10 kV m^{-1}/ work shift;

30 kV m^{-1}, short time exposing in the field;

500 μT/ work shift;

5 mT, less then 2 hours exposing;

25 mT, short time exposing of the human body extremities.

The maximum exposing time for electrical fields between 10 kV/m and 30 kV/m, could be calculated with: $t \leq 80E^{-1}$, where t is the length of a day's work and E is the electric field strenght in kV/m.

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