© 2023 IJNRD | Volume 8, Issue 10 October 2023 | ISSN: 2456-4184 | IJNRD.ORG

IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

"Biological Effects of Electromagnetic Interference of High Voltage Transmission Lines on Human Body"

Raju Bhuvane (M.tech student), Shri Rawatpura Sarkar University Raipur
Dr. Mithilesh Singh (HOD Electrical Department), Shri Rawatpura Sarkar University Raipur
Mr Vijay Prakash Gupta (Assistant Prof.), Shri Rawatpura Sarkar University Raipur, india

Abstract-Electromagnetic radiation has turned into a major threat to humans from sources like mobile phones, transmission lines and many more electrical appliances. An ecological problem with increasing sensibility is seen. For providing continuous and uninterrupted supply of electric power to consumer's maintenance, operation of high voltage power lines are often performed with systems energized. In planning high-voltage lies, the magnetic and electric field quantities have to be examined in order to avoid EMC problems with the surroundings of the power line. The main aim of this paper is to create a model for human body and transmission line using Ansoft Maxwell. Mathematical model for operation of EHV lines have been developed using MATLAB considering time- varying magnetic fields expressed in second order differential equation. The effect of EHV lines will be measured and the safe limits for human interference with electromagnetic fields will be determined.

Key words- Calculation of EMF, Modelling of human body

I. INTRODUCTION

For millions of years, all living organisms have existed within a natural electromagnetic environ-ment determined by the earth's electric and magnet-ic fields, the sun's electromagnetic activity, cosmic ionising and non-ioniz-ing radiation (including "cosmic microwaves"), and terrestrial radioactivity consisting of γ radiation and charged particles. These natural electromagnetic field/radiation sources provide a continual flow of electromagnet-ic energy within which all living beings exist. With the exception of static terrestrial fields and cosmic microwaves, this natural electromagnet-ic environment has a relatively constant intensi-ty level most of the time, and living organisms have adapted to this stable electromagnetic environment for millions of years. Nonethe-less, fluctuations in the regular levels of natural fields of the order of 20% occur during "magnetic storms" caused by enhanced sun activity. Dur-ing these changes, which normally last a few days, there is a significant increase in health problems in people and all living things on Earth.

Man-made EMFS (such as those associated with power lines) and wireless communications radiation at frequencies below the low limit of infrared have arisen at very high rates over the previous century and notably in the last decades. These unnatural (manufactured) EMFs differ from natural ones primarily because they are polarised, changing, usually modulated, and produced in a continuous manner by electric/electronic oscillation circuits. These manmade EMFS combine with natural environmental EMFS, increasing the exposure of living creatures to EMFS and resulting in "electro-magnetic pollution."

Adverse health effects of low frequency electric and magnetic fields research began in the early 1970s, when papers were produced on the effects of overhead lines on the health of utility staff exposed to electric fields. Epidemiological studies have rekindled interest in the potential health impacts of alternating current electric and magnetic fields. These investigations linked medical problems such as headaches, central nervous system disruptions, physiological and psychological effects, hormone and enzyme processes on cell membrane surfaces, bone cancer, and blood cancer to exposure to strong alternating current electric and magnetic fields. It was discovered that exposing tested rats to relatively high electric and magnetic fields for 20 to 24 hours a day can cause dizziness, decreased activity, panic, and loss of appetite. All engineering investigations found that biological impacts from field exposure are possible. Additional research was recommended for all of these reviews. Magnetic fields that change over time may interact with living organisms.

Electric currents can be induced in stationary conducting objects by time-varying fields, including extremely low frequency (ELF) fields. Thus, time-varying electric fields can initiate all kinds of interaction with biological matter, while static magnetic fields cannot Because very strong external (ELF) electric fields are necessary to generate even tiny internal fields, a time-varying magnetic flux will induce electrical potential difference and eddy currents across the conducting channels. The health and environmental effects of high voltage transmission lines have been split into two major research areas. The first step is to investigate the potential impacts of electrical and magnetic fields in the area of the line. The second is as a result of the electrical discharges and ionisation caused by these lines.

Table 1: Maximal exposure values for the magnetic field

	Workers (mT)	General public (mT)
2 hours a week	5.0	-
A whole day	0.5	0.1
For limbs	25.0	-
A few hours a week	-	1.0

II. NUMERICAL ANALYSIS

Solving the electric field problem each segment of the line model represents a constant line charge. In the case of evaluating the magnetic field distribution each segment of this polygon represents a current. Using this mathematical model the point matching method can be applied to solve the electric field problem and the BIOT SAVART law determines the quantities of the magnetic field, respectively. Due to linearity, the superposition of the partial field values of the single conductors or segmented filaments respectively, results in the overall three dimensional field distributions below the high voltage line. It is assumed that only symmetric rotary voltage and current systems are taken into consideration. The ground below the transmission line is considered to being an even plane. To consider the slack of the conductors a quadratic approximation is used Bundle conductors are taken to account with an equivalent t radius.

A. Calculation Procedure for the Electromagnetic Field

All calculation methods for electromagnetic fields can be subdivided into two classes, numerical and analytical methods. Both types of methods are based on solving the Maxwell equations for the electromagnetic field, and each method has its own [5:34 pm, 21/09/2023] aurtsurya00: drawbacks. In the analytical methods, some assumptions are always used. On the other hand, the accuracy of numerical methods, such as the finite- element method, is conditioned by the applied partition of the continuous space into elements. Yet, the analytical method is less laborious, and its application seems to be more justified provided that the adopted assumptions are valid. In the analytical method, the electromagnetic field is calculated under the following assumptions:

1. The current density in all conductors is uniform, i.e., the proximity effects for the wires and components of bundled phase conductors are disregarded;

2. The conduction current in the ground is negligible;

3. The influence of the extraneous (human) body on the field pattern in air is also negligible;

4. Longitudinal currents in the ground can be ignored."

According to [4] an analysis for wires treated as narrow linear conductors and for wires whose finite dimensions are taken into account the modeling, the magnetic fields in the dielectric were almost identical. Hence, the first assumption in the calculation of the HV Transmission line magnetic field is proved valid According to Carson, the second assumption introduces no serious inaccuracies in the calculated data at frequencies below 1 MHz and at specific resistances of the ground not lower than 100 Ohm-me The third assumption is related with the average electrical conductivity of human tissues of about 0.04 S/m. For this conductivity, the skin depth for 50-Hz electromagnetic waves amounts to 250 m.

The latter depth being much larger than human-body sizes, the third assumption is justified. The fourth assumption was validated through comparison of analytical and numerical calculations of HV PL electromagnetic fields. The numerical calculations were performed using the ANSOFT program package; in these calculations, a value of 100-500 Ohm-m was adopted for the specific resistance of the ground On the other hand, under the adopted assumptions the PL electromagnetic-field intensity due to each HV Transmission line wire (a total of n conductors) can be calculated by the formulas:

$$H_i = \frac{I}{2\pi\sqrt{(h-z)^2 + y^2}},$$

$$H_{yi} = H_i \cos\varphi_i, H_{zi} = H_i \sin\varphi_i,$$

$$tg\varphi_i = \frac{h-z}{(y+d)},$$

$$H = \sqrt{(H_{y1} + H_{y2} + .. + H_{yn})^2 + (H_{z1} + H_{z2} + .. + H_{zn})^2}$$

Here, z is the coordinate of the point at which we calculate the intensity, d is the distance between thispoint and the nearest PL tower, and h is the height of wire suspension over the ground level.

III. MODELING USING SOFTWARE

A. Induction currents in a human body acted upon by a 50-hz electromagnetic field

Presently, the action of a magnetic field of industrial frequency is characterized just with the absolute value of the magnetic field disregarding the direction of the field vector. For instance, in Europe the specified modulus of the field vector is 80 A/m. Nonetheless, for different field vector orientations with respect to the human body the harmful induction currents differ in value. In the present study, the Influence of the field-vector orientation on the values of induced currents was analyzed based on the numerical solution of Maxwell equations for the total current and electromagnetic induction supplemented with appropriate boundary conditions.

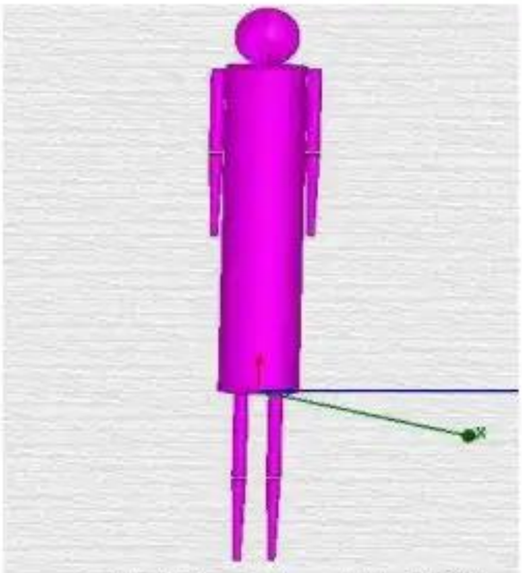

Fig 1: Human body modeled with FEM

B. One method to analyze body model is segmental phantom:

Body model segmental body analysis can be accomplished by computing segmental body impedances. It is meant to be a simple model that allows for the quick estimation of segmental impedances without the need for complex software. Six distinct portions in which the impedance exhibits characteristic behaviour can be identified in the simulation data. This includes the lower leg, knee, upper leg, chest, upper arm, and lower arm. Homogeneous cylinders are used to model sections with linear impedance. Homogeneous cut-off cones are utilised in the lower limbs, where the impedance steadily increases. The sections are summarised below:

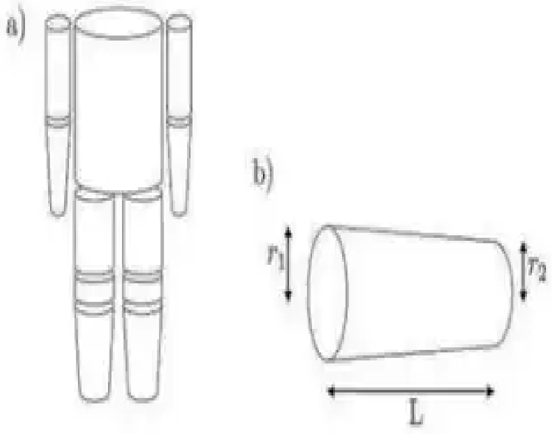

Fig 2: An overview of sections

The resistance of a cylinder with the length L and a radius r is given by:

$$R_{cy1} = \frac{\rho L}{\pi r^2},$$

where p is the specific resistivity of the material. The geometry of a cut-off cone is drafted in Fig. 2. Its resistance can be calculated using:

$$R_{cone}(l) = \frac{\rho L}{\pi(r_1 - r_2)}\left[\left(r_1 + \frac{r_2 - r_1}{L}.l\right)^{-1} - \frac{1}{r_1}\right],$$
$$0 \le l \le L.$$

In case of the full cut-off cone this simplifies to

$$R_{cone} = \frac{\rho L}{\pi r_1 r_2}.$$

In order to fit the resistance values of the simple phantom to the simulation results, the geometry and conductivity of each section have to be estimated. This is done in several steps:

- L is measured.
- The resistance of the complete section R is obtained from the simulated curve.
- Cylinder: r is measured. Cone: The averaged radius is measured; r1 and r2 are varied for an optimal fit.

$$r_{avg} = \sqrt{r_1 r_2}$$

For the cylinders, ρ can be obtained from $\rho = \frac{\pi R r^2}{L}$, for cones $\rho = \frac{\pi R r_1 r_2}{L}$ is used.

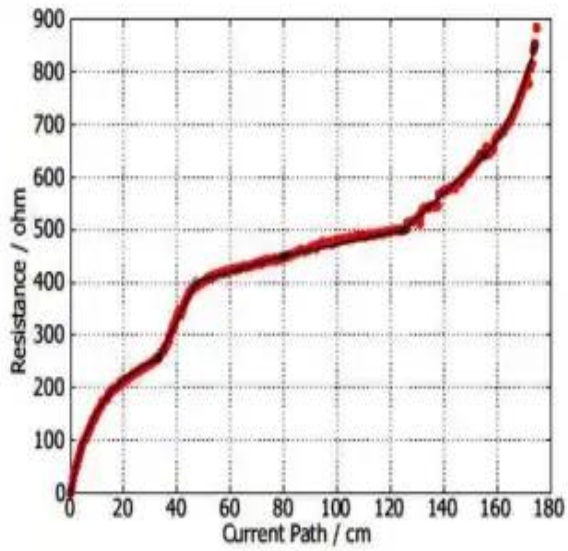

Fig 3: Comparison of the simulated impedances (red circles) to the values obtained with the simple stylized phantom (dark line) [6]

Table below shows the geometry and conductivity data for the six sections of the simple phantom obtained to fit the simulation data at 50 Hz. A comparison between the estimated impedances by the simulations and by the simple phantom is shown in the figure above with Red circles represent simulation data; the dark line depicts results obtained from the phantom. The resistance values calculated using the simple phantom or human body agree very well with the results from simulation data, confirming the validity of the simple model.

Table 3: Parameters for the simple phantom or human body at 60Hz.

Segment	Type	L /cm	r_1 /cm	r_2 /cm	R /Ω	P / Ωm
Lower leg	Cone	33	2.25	7.84	255	4.28
Upper leg	Cylinder	33	9	9	50	3.86
Torso	Cylinder	15	25	25	50	21.83
Upper arm	Cylinder	30	3.5	3.5	135	1.73
Lower arm	Cone	20	3.5	1.79	215	2.11

C. Transmission line model using Finite Element Method

Maximum values for the field quantities are supplied, a cross-section of the transmission line is made at the place where the wires are closest to the ground level. A 3 dimensional finite element mode lateral to the line at this place is build. The potential distribution over each element is approximated by a polynomial. Instead of solving the field equations directly, the principle of minimum potential energy is used to obtain the potential distribution over the whole model.

D. 3 Dimensional Mesh generation

The ratio of the largest size of a finite element to the smallest size in a finite element model of a transmission line is about 10,000. The circular boundary of the model has a radius of about 100 m, while the radius of the conductors is a few centimeters. Therefore special attention must be paid to obtain a regular mesh with good shaped elements. This ensures an accurate solution of the field problem. The change in the size of the elements in the direction away from the conductor can be computing the electric field strength it is assumed that the ground plane below the transmission line is considered being an equipotential surface. Contrary to this, in the model for the magnetic field calculation the ground possess the same magnetic properties as the surrounding air and Magnetic field intensities in the corridors of HV Transmission lines.

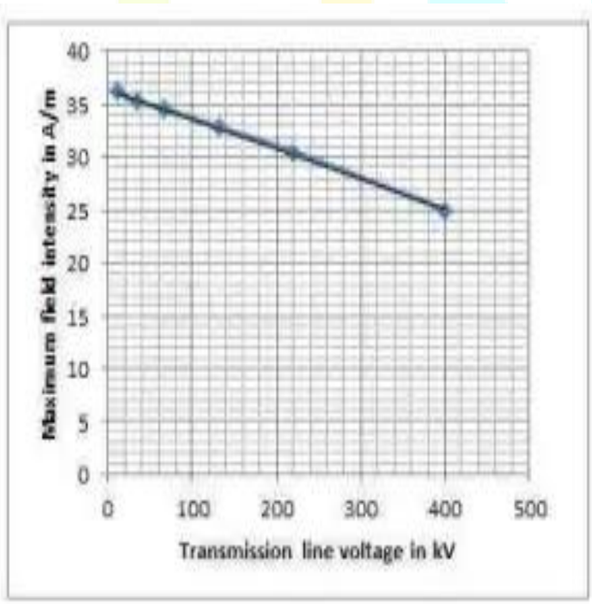

Fig. 4(a): graph of transmission line (PLs) design and field intensities.

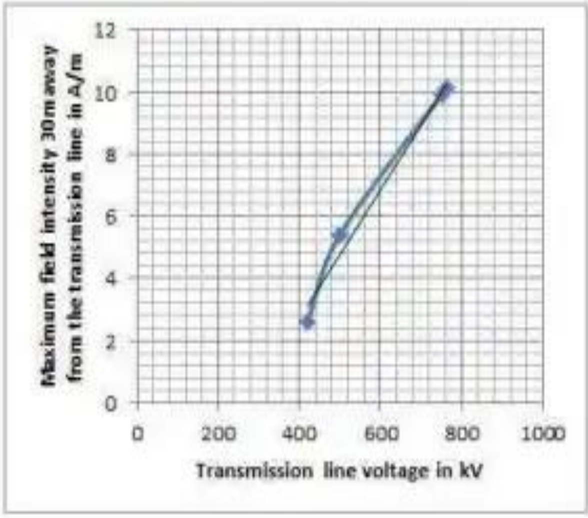

Fig 4(b): graph of transmission line (PLs) design and field intensities 30 m away from line

IV. RESULTS

The figures below show the field distribution in transmission line and induced effect in the human body which are modeled and simulated using FEM.

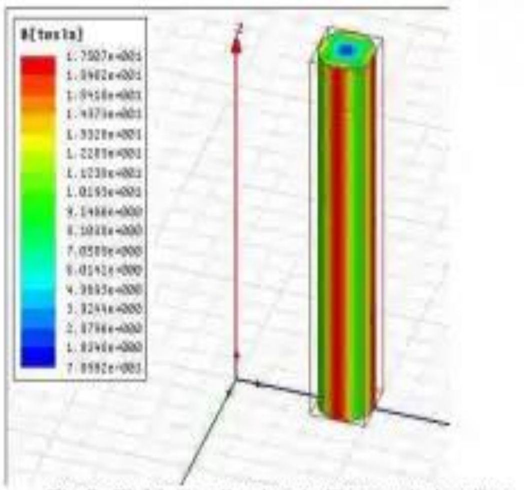

Fig 7: Field distribution in Transmission line conductor

The line considered is 400kV line with the field intensity of 1.9A/m 30m away from the transmission lines. [Fig 4(b)]

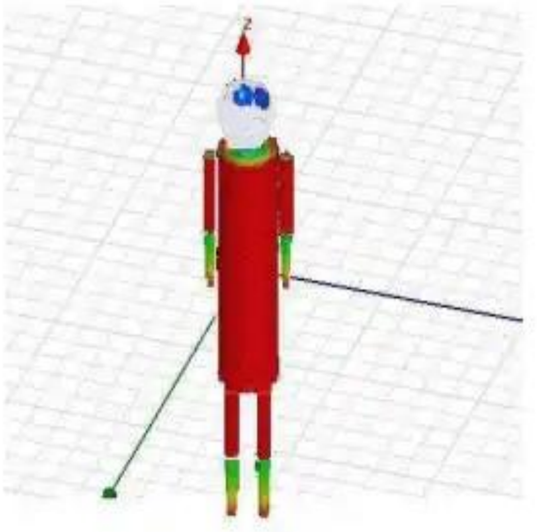

Fig 8: Field distribution in human body induced due to Transmission line

Human body values were calculated and the values are given in the below table-

Table 4: Conductivity Values of Human Body

Body parts	Conductivity values in siemens/m
Head	3.9363
Torso	6.157
Upper arm and Upper leg	1.332
Lower arm and Lower leg	1.235

Unfortunately, to date no definite recommendations on the repair technology of hot HV can be formulated (concerning the danger of human stay in an intense magnetic field). All measures presently taken during such repair works are aimed at the reduction of the field level. Yet, the risks related to such stay still remain poorly investigated.

V. CONCLUSION

- The electromagnetic fields in the corridor of HV Transmission lines can be adequately calculated by analytical procedure.
- The maximum strength of the total magnetic field is found to be around the center conductor of the line.
- Electric and magnetic fields associated with the transmission lines have adverse health effect on any life near it.
- It is insufficient to characterize the limiting value of the magnetic-field intensity just with the field vector modulus: it is also required to observe the orientation of the magnetic-field vector with respect to human body and the action of induced currents on body parts. This circumstance must be taken into consideration when organizing hotline repair works.
- The matter whether it is possible or not to execute hot-line repair works on particular HV Transmission lines is to be considered with obligatory performance of biomedical tests since only in such tests limiting acceptable values of induced currents in different parts of human body can be evaluated.

VI. REFERENCES

[1] Kay Hameyer, Ronny Mertens and Ronnie Belmans, "Numerical methods to evaluate the Electromagnetic Fields below overhead transmission lines and their measurement", Katholieke Universiteit Leuven, E.E. Dept. ESAT/ELEN, Kardinaal Mercierlaan 94, B-3001 Leuven, Belgium.

[2] Ahmed A. Hossam-Eldin, "Effect of Electromagnetic Fields from Power lines on living organisms", 2001 IEEE 7th International Conference on Solid Dielectrics, June 25-29,2001, Eindhoven, the Netherlands 438.

[3] Lucio Ippolito, and Pierluigi Siano, "Magnetic Fields Mitigation by Using Multi-objective Optimal Power Flow", Department of Electrical&Electronic" Engineering University of Salemo -Via Ponte don Melillo, 1-84084 Fisciano (S4)-Italy

[4] K.P.Kadomskaya and IM Stepanov, "Effectiveness Evaluation for Measures to Minimize Hazardous Electromagnetic Environment around, Overhead High-Voltage Power Lines".

[5] Dimitris J. Panagopoulos, "Electromagnetic Interaction between Environmental fields and living Stems determines health and well-be-

ing", University of Athens, Department of Biology, Athens, Greece Radiation and Environmental Biophysics Research Centre, Athens, Greece,

[6] Dipl. Phys. Andreas Barchanski. "Simulations of Low-Frequency Electromagnetic Fields in the Human Body".

[7] Abdelmalek Laissaoui, Bachir Nekhoull, Kamal Kerroum, Khalil El Khamlichi Drissi, and Dragan Poljak, "On The Rotationally-Cylindrical Model of the Human Body exposed to ELF Electric field", Progress In Electromagnetics Research M. Vol. 29, 165-179, 2013.

[8] N. Siauve, R. Scorretti, N. Burais, L. Nicolas, A. Nicolas, "Electromagnetic fields Human Body: a new challenge for electromagnetic field computation", hal-00140339, version 1-18 Apr 2007,

[9] Girish Kulkarni, Dr.W.Z.Gandhare, "Proximity Effects of High Voltage Transmission Lines on Humans", ACEEE Int. J. on Electrical and Power Engineering, Vol. 03, No. 01, Feb 2012.

[10] P. Pao-la-or, A. Isaramongkolrak, and T. Kulworawanichpong, "Finite Element Analysis of Magnetic Field Distribution for 500-kV Power Transmission Systems", Engineering Letters, 18:1, EL 18 1 01.

[11] S. Tupsie, A. Isaramongkolrak, and P. Paola- or, "Analysis of Electromagnetic Field Effects Using FEM for Transmission Lines Transposition", International Journal of Electrical and Computer 1 Engineering 5:4 2010.

[12] Dimitris J. Panagopoulos, "Electromagnetic Interaction between Environmental fields and Living systems Determines Health and well-being", Electromagnetic Fields: Principles, Biophysical Effects.

[13] Dejan M. Petkovic, Dejan D. Krstic, Vladimir B. Stankovic, "The Effect of Electric field on Humans in the Immediate Vicinity of 110 kV Power Lines", Working and Living Environmental Protection Vol. 3. No 1, 2006, pp. 63-72

[14] Frederic G. Hirsch, E. Clinton Texter, Jr., Lloyd A. Wood, William C, Ballard, Jr., Francis E. Horan, Irving $. Wright, Constance Frey and Dorothy Starr, "The Electrical Conductivity of Blood: I Relationship to Erythrocyte Concentration", bloodjournal hematologylibrary.org.