Engineering Ethics Cases with Numerical Problems

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Electrical Engineering Case 8

High Voltage Lines

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I. Narrative

Electrical energy involves power generation, transmission, and distribution. The latter two involve DC or AC lines with varying voltages. The largest known DC voltage is approximately 1 million volts. AC transmission lines employ voltages ranging from 66 kilovolts to several hundred thousand kilovolts. Since there are no high voltage DC lines in cities, the only concern is from high voltage AC lines to substations. These lines carry currents producing circumferential magnetic fields which exceed the IEEE standard (about .4 microWebers/ square meter for magnetic flux density and .03 W/kg for S.A.R.).

These lines produce high intensity electromagnetic fields. The most recent concern has been the magnetic fields from high voltage transmission lines in residential areas. Possible effects of the magnetic fields are malignant tumors and genetic mutations.

The voltage in residential areas is constantly increasing because of the rising number of lines, the higher voltages being used, and the number of homes being built near them. It seems that the highest exposure times correspond to the times of day that the electrical power consumption is the highest.

The easiest way to minimize the magnetic flux density levels to individuals is to build homes such that a grounded, metallic, mesh screen is installed on the roof and in the walls while the house is being constructed.

II. Numerical and Design Problems

1. Calculate the magnetic field intensity (**H**), the magnetic flux density (**B**), and the

electrical field intensity (**E**) for various values of line voltage as a function of distance and plot your answers on a coordinate system. (Start with a voltage value of 230 kV and

a distance of 100 meters.) Estimate the corresponding specific absorption rate (S.A.R.) values for whole body exposure ([1],[2]).

2. Calculate the same values as in question 1 for varying values of line current as a

function of distance. Plot your findings. (Start with a current of 100 Amperes).

3. Assume that the subject is completely enclosed in a grounded, mesh screen (1mm^2 mesh). What effects would this have on the **H**, **B**, and **E** (at 230 kV, 100 Amp, and 100m)?

4) Repeat question 3 for a typical home that is protected by the same mesh screen. (Make

assumptions as necessary).

III. Questions on Ethics and Professionalism

1. A real estate agency hires a contracting firm to build a subdivision in a certain rural area. The job is worth millions of dollars to the firm. When the contractors visit the site they see that there are high voltage power lines in great numbers running over it. They approach the real estate company with a suggestion of installing the protective mesh in the homes. After discussing the price increase involved, the real estate agency refuses to pay for the protection. Should engineers employed by the contractors recommend that the contractors build the homes without the mesh or should they absorb the cost themselves?

2. What about homes that are already built? If power companies put high voltage power lines in an already existing residential area, who would the burden of cost fall on?

References

[1] Gandhi, O.P. 1990. Biological Effects and Medical Applications of Electromagnetic Energy. Prentice-Hall.

[2] Kraus, John D. 1988. Antennas 2nd Edition. McGraw-Hill. Chapter 5.

IV. Solutions

1)and 2) The magnetic field intensity at a radial distance r from the axis of the conductor carrying current I is given by:

$\mathbf{H} = I / (2r) = 100/ (2r) = 1/2$ Amps/m

and the magnetic flux density as

$\mathbf{B} = {}_o \mathbf{H}$ when ${}_o = 4 * 10^{7}$ Henry's/m

These plot as a family of hyperbolae starting at infinity (for r o) and going to zero (for r 0s). As I increases, the curves shirt further into the first quandrant.

Assuming I = 100 Amps and r = 100m we obtain

B = 4 * 10 ^{7} (100 \ (2 * 100)) = .2 microWebers/ m^2

3) and 4) The idea of the mesh screen is to alleviate the radiation going into the subject or home. So hopefully the values of **H**, **B**, and **E** will be zero. This is somewhat of a design problem.

V. Solutions to Questions on Ethics and Professionalism

The IEEE code requires engineers to "accept responsibility in making engineering decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment." True, the engineer's minimal responsibility is to make it known to employers and perhaps others in authority when they believe technology poses a threat to public health, safety and welfare.

There is evidence that transmission lines do pose such a threat, so engineers employed by contractors have a responsibility to make the dangers known and recommend solutions. But, the National Society of Professional Engineers (NSPE) code requires engineers to "protect" the health and safety of the public. This may require engineers to do more than simply inform authorities of the problem. Even if it does not, the engineer's personal morality may require more.

If the law does not require the installation of the metallic mesh screens, engineers who might be involved in the design of the subdivisions or other facilities related to the project have the choice of complying with the contractor's wishes or not participating in the project. If they back out, they know that their own refusal will not keep the unprotected houses from being built, they should probably refuse to participate in the project. Otherwise, they will be participating in something they believe poses a substantial risk to public health.

If engineers are convinced that the transmission lines pose a serious health problem, they should probably also encourage their professional societies to lobby for legislation requiring installation of the metallic mesh screens in areas exposed to high intensity electromagnetic fields.

If engineers are asked to design transmission lines through residential areas where the homes are not protected, and if they are convinced that the lines pose a serious health risk, they should insist that the residents be warned of the danger. Again, engineers might want to encourage their professional societies to lobby for legislation requiring that transmission lines not be built near existing homes, or that the homes be properly protected.