Engineering Ethics Cases with Numerical Problems

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Electrical Engineering Case 7

Cellular Phones: Reach Out and Touch Someone?

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Antenna Thy/Des

Level:

Junior

I. Narrative

Cellular phones are one of the most popular items on the market today. They are attractive and extremely convenient, with some phones transmitting and receiving signals in the 800 MHz band and up to and beyond a 30 mile radius. Lately cellular phones have been in the news. A Florida man sued a cellular phone manufacturer after the death of his wife. His wife died of a cancerous tumor in the brain allegedly caused by her cellular phone.

The problem originates with the frequency and the location of the antenna. Under normal circumstances, the antenna is very close to the skull and has an isotropic radiation pattern (360 pattern of radiation) in the azimuthal plane and a figure eight pattern in the elevation plane . Approximately one half of the power is dissipated into the brain. Therefore, the near field effect on the brain needs to be investigated at normal operating intensity.

Very little is known about the near field effects of radiation on the body, especially brain tissue. IEEE has proposed a standard of how much radiation could safely be dissipated into the human body as a whole. This standard is .4 Watts/kilogram. This is an average for the entire body, but recent research shows that the tissue of the brain is much more susceptible to radiation. This means that the standard for the brain should be significantly

lower than the IEEE standard. How much lower no one is sure, since the effect of radiation on the brain is unknown.

II. Numerical Problems

Problem 1. Using the following formulas, calculate the electromagnetic fields radiated by the antenna as a function of distance. ([2],[3]) See diagram.

$E_r = I_o L \cos e^{j[t-(r/c)]} [(1/cr^2) + (1/jr^3)]$

2

$E = I_o L \sin e^{j [t-(r/c)]} [(j/c^2r) + (1/cr^2) + (1/jr^3)]$

4

$H = I_o L \sin e^{j [t-(r/c)]} [(j/cr) + (1/r^2)]$

4

Problem 2. How would these numbers be modified in the presence of a human brain?

Problem 3. How much power is dissipated into the brain? Does this exceed the IEEE standard?

The specific absorption rate (S.A.R.) formula is as follows ([1]):

S.A.R. = E^2

2

Where is the electrical conductivity of the medium in Siemens/meter and is the mass density

of the tissue in kilograms/meters cubed.

Approximate values for the human brain are as follows: = 1050 kg/m^3 , = .65 S/m at 350

MHz, and $_r$ = 60 at 350 MHz.

4) How would you modify the design of the antenna to minimize or alleviate the S.A.R. level to

the brain?

III. Ethical Problems

1. Andrew is a young engineer working for a cellular phone manufacturing company. When doing a bit of off the job research he read the latest report about the susceptibility of the brain to radiation. The next day he reviewed the calculations of the radiation given off by the antenna of his company's hottest selling cellular phone. He found that the S.A.R. to the brain was .35 W/kg. Later that afternoon he visited his boss with a suggestion to modify the antennas on the phones and perhaps doing a recall on the ones already sold. "Andrew," screamed Diane, head engineer, "what you're suggestion would cost us hundreds of thousands of dollars! You can't possibly be serious. That's our fastest seller. Recalling them would be a disaster and there are more important things to be done. You don't even know that this is dangerous!".

" But what about our obligation to the public?"

"What about your obligation to the company? Look, I don't want to make a big issue out of this. We're within IEEE standards and unless we have further word from them then we're in the clear."

What would you do if you were in Andrew's shoes? Would you talk to someone above Diane or try to convince her, etc. ? Can you think of options that would be fair both to the company and to the public, especially in the light of the uncertainty about the health risks? Explain your reasoning.

2. Assume that Andrew asks Diane for paid time to research the matter further and Diane refuses his request. Now what should Andrew do? Discuss your rationale.

References

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

Prentice-Hall. Page 7.

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

[3] Lee, K.F. 1984. Principles of Antenna Theory. Wiley. Chapter 3.

IV. Solutions to Numerical Problems

1) using equation #2 and assuming the following values:

r = 5cm

I_o = 1 Amp.

f = 800 MHz

L = (c/f)/4 = /4 = $(3*10^8/ 800*10^6) / 4$ = 9.4 cm [wire length]

W = 2f = $2800*10^6$

$_o$ = $8.854*10^{-12}$ Farads/meter [for free space permeability]

= $_{o}$ $_{r}$ (in the absence of the brain $_{r}$ is taken out of the equation, therefore for this

question = $_{o}$)

= 90

After doing the math, the value of $_{o}$ is 1198.8 V/M

2) In the presence of the human brain, $_{r}$ is equal to 37 (assumed for the brain at 1 GHz [1] pp

88,89, and 121). After adding this into the equation.... $_{o}$ = 32.4 V/M

3) Using the S.A.R. equation (.81 * $(32.4)^2$) / 2*1050 = .41 W/kg. This exceeds the IEEE

standard by .01.

4) One way to alleviate the problem is to design an antenna that is perpendicular to the brain rather than parallel to it. Meaning that the antenna would be at a 90 angle. This would make

= 180 , which would in turn make S.A.R. value very near 0.

V. Solutions to Questions on Ethics and Professionalism

1. Andrew's situation could be described as a "conflict problem". That is, he is caught between an obligation to protect the health of the public and an obligation to be a loyal employee. The first thing he should do is get as much information as he can about the facts. Just how harmful is the radiation from the company's cellular phones? How expensive would it be to recall the phones? Is IEEE about to change its standards? What legal liabilities could the company face from the harm to the public?

After this, Andrew should attempt to come to a "creative middle way" solution to the problem. That is, he should try to propose a course of action for himself that would satisfy both his obligation to the public and his obligation to be a loyal employee. If his research concludes that the cellular phones are indeed a danger to the public, he might conclude that the company is liable for lawsuits, even if the radiation does fall within IEEE standards. After all, automobile manufacturers have gotten into trouble with the government and the public, even in areas where they followed government standards. If Andrew could come up with a low-cost modification of the phones, he might be able to convince Diane that a recall would not be too costly, that the recall would ultimately result in a public-relations coup for the company, and that it could avoid or mitigate costly litigation later. He might argue, for example, that the company could emphasize that it was making the recall, even though its product falls within all of the legal and professional standards and that the new or refurbished phones are the safest on the market.

If Andrew's research concludes that the radiation danger is not significant, or that it is not clear what the danger is, he may choose a different option. If he concludes it is not clear what the danger is, for example, he may try to persuade Diane that new phones should be made safer, even though the old ones should not be recalled. He can argue that the company could advertise its new phones as safer than those of the competitors.

Insofar as possible, he should make specific proposals as to how the phones can be made safer. At the very

least, he should make specific proposals as to how research should be done to find the best way to make the phones safer.

In making his proposals to Diane, Andrew should attempt to avoid a confrontational tone. He should not make his case in terms of "You have a problem", but in terms of "We have a problem". He should not threaten to blow the whistle or disrupt the organization, but make every effort to present himself as a team player who is interested in the welfare of the organization as well as the welfare of the public.

2. If Andrew finds that the radiation appears to be a serious health risk and Diane refuses to honor his request for paid time for further research, Andrew might ask permission to do some research on his own time and at his own expense. Such a request would probably impress Diane with his own sincerity and dedication. He could offer to make any results of his research known to the company.

Of course Diane could interpret Andrew's motives in a negative way and come to believe that he is an untrustworthy employee. She might forbid Andrew's using company property or equipment for the research and even warn him that such activities, even on his own time, will be viewed with suspicion. In this case, Andrew must decide whether to do the research, stop his protest, move to another company, or blow the whistle. His decision will be based on many factors, including the seriousness of the danger to the public, the likelihood of a change in regulations that will solve the problem without his intervention, the danger to his own career, the likelihood of other employees agreeing with him, and so forth.

If Andrew thinks the problem is very serious indeed, and finds no creative middle way is possible, whistle blowing might in some circumstances be required. But it should always be a last resort. In this unfortunate event, he should try to enlist the support of other professionals, document his moves carefully, provide good reason for his action and try to be as non-confrontational and professional as possible.