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The Effect of Distance of Human Head Model from EM Sources on SAR

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ABSTRACT

The probable effects of electromagnetic fields on human body and tissues have lead some researches to investigate the adverse biological effects on the human health. Some of these effects are on the human cells, which is the subject of this paper. A discussion of dosimetry is introduced. The human head and an antenna as an exposure source are simulated. The effects of variation of distance of head from exposure source on E-field strenght, H-field strenght and SAR is simulated. The electric and magnetic field and SAR distributions are shown in simulations at 900MHz by HFSS software. The results show that by increasing the distance from exposure source, the E- and H-fields and SAR, are increased.

KEYWORDS - human body; frequency; EMF; bioeffect; HFSS software;

INTRODUCTION

The biological effects of exposure to electromagnetic fields (EMF) at extremely low frequency fields (ELF) and radio frequency (RF) radiation is an important subject for human life. Many scientists have used different types of exposure sources to evaluate the probable effects of electromagnetic wave (fields) on the human body. When the body is exposed to EMF sources, several factors influence SAR, such as body shape and size, frequency of field, exposure environment, source structure, geometry of tissues and wave polarization. The probable bioeffects of electromagnetic field sources like cell phones are noticeable, because such devices are widely used in the human communities. The electrical properties of biological bodies are conductivity and permittivity. Gabriel et. al obtained electric properties for 40 types of tissues. However, some reports give different values for the same tissues too.

DIELECTRIC PROPERTIES OF BODY TISSUES

The dielectric properties of tissues, such as permittivity, permeability and conductivity have important roles in the interaction between fields and human body. The permeability of biological tissues is approximately equal to mu0, and they don't effectively change with frequency. However, the dielectric constant varies with frequency as shown in Fig. 1. The permittivity of tissues has some relationship with the water content. For example, tissues such as fatty substances have low water content, blood has high water content and muscle has intermediate water content.

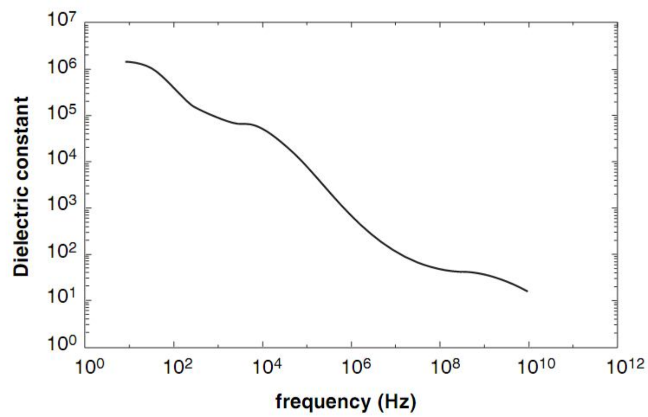

Fig 1. Dielectric constants of living material as a function of frequency

INTERACTION OF FIELDS AND HUMAN BODY

The biological effects of fields depend on the field strength and internal fields. The relationship between environmental exposures and induced EM fields in the body is often named dosimetry. Dosimetry is used to account for the level of exposure as well as its duration. A biological body is a lossy dielectric material, which makes the modeling of

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biological body difficult. On the other hand, the experiments of fields on the human body is very dangerous. Therefore, the EM tests are done on animals and their results may be extended to humans by the following formula:

$$l_a \cdot f_a = l_h \cdot f_h \qquad (1)$$

Where f_a and f_h are animal and human frequencies, respectively. These conditions are often used in a modified form termed frequency scaling. Frequency scaling is true when there are no losses, because with losses present the Maxwell's equations have an extra term, which changes the scaling factor from one model to another

The biological effects of fields are a current subject matter to researchers now, which have applied various methods. The effects of fields on the children may be more than the adults, because of their smaller body sizes and the growing states of their bones. Here the results of cellular studies are described. Damages on cells may lead to cancer and other diseases. Genotoxic effects are the DNA single and double-stranded breaks in the brain cells, damage to chromosomes, induction of sister chromatic exchange (SCE). Nongenotoxic effects include changes in cellular function such as: gene expression, cell proliferation and cellular signal transduction. The energy of electromagnetic fields absorbed by a biological organism converts into heat in the body. If the heating is higher than the normal range of organism, the temperature will rise and thermal effect may incur. Blood flow and sweating may be sufficient to remove the temperature rising in body and prevent any heating.

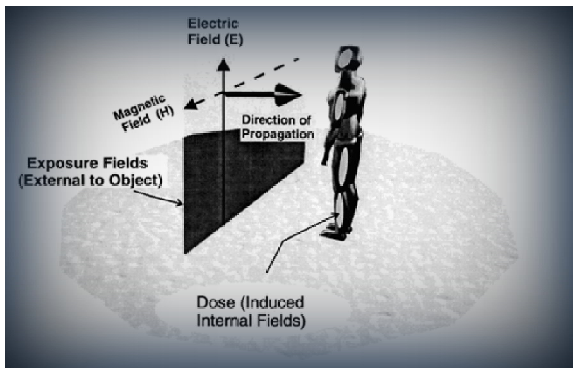

Fig2. Distribution of impact field in human body.

SPECIFIC ABSORPTION RATE

The fields from exposure sources are absorbed by the human body. The absorption rate are related to some parameters, such as source shapes, body tissue sizes and the dielectric properties of tissues. The effects of electromagnetic fields at high frequency range of frequency spectrum are expressed in SAR unit. SAR is the specific absorption rate (i.e. the energy absorption per mass of tissue), which is directly related to the electric and magnetic field strength distributions in the tissues. It is applied for the evaluation of field effects on human body. SAR is related to conductivity and E- field directly.

$$SAR \propto \sigma E^2 \qquad (2)$$

The Specific Absorption Rate (SAR) is defined as the time derivative of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given mass density (r).

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho . dV}\right) \qquad (3)$$

$$PLD = \frac{d}{dt}\left(\frac{dW}{dV}\right) \qquad (4)$$

The SAR value is expressed in units of watts per kilogram (W/kg). The Power Loss Density (PLD) value is expressed in units of watts per cubic meter (W/m^3), as given in eqs 3 and 4.

Whole-body-averaged SAR: The value is obtained by dividing the total power absorbed in the human body by the full body weight. It is also possible to define a sub volume by picks or by numbers.

Local SAR: SAR is given as a numerical value per volume element and becomes a space distribution function. For this function, the mass mean value in arbitrary tissue volume is called local SAR. Typical local SAR values are averaged in tissue masses of around 10gr and 1gr.

SAR MEASURMENT IN HUMAN HEAD MODEL[13]

The measurement of SAR is not easy in the human body, but the simulations with various soft wares are recommended methods for estimation and evaluation of biological effects of electromagnetic fields. Some parameters affect the SAR, such as frequency, tissue geometry, size and electrical properties.

We now evaluate the effect of distance from the exposure source on SAR, with a standard model having the following characteristics. The head model is a bowl with internal radius 11.65 cm, external radius 10.65cm, relative permittivity 4.6 and the head equivalent material put into the bowl. The source exposure is a 16.15cm dipole antenna mounted on a handset with 10cm*5cm*3cm dimensions. The model is shown in Fig.1. All the simulations are at 900MHz and the tissue equivalent material properties are given in Fig.3. All the simulations are at 900MHz..

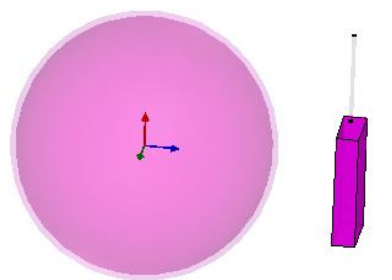

Fig 3. Head model in HFSS

RESULTS OF SIMULATIONS

The effect of distance from source exposure on SAR has been simulated. The electric and magnetic field strength distributions have also been computed. The results are shown in Fig.4 to Fig.12 for 3 distances i.e. 6 , 8 and 10 cm.

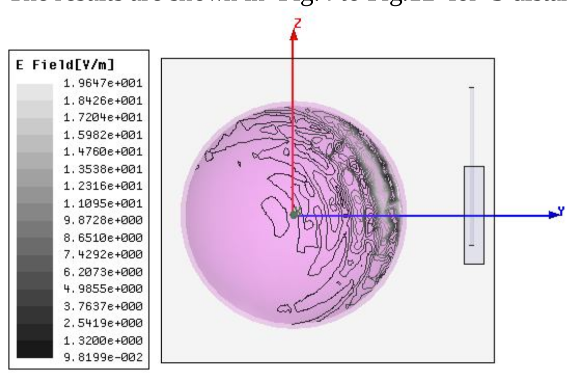

Fig4. Electric-field strength at 6cm.

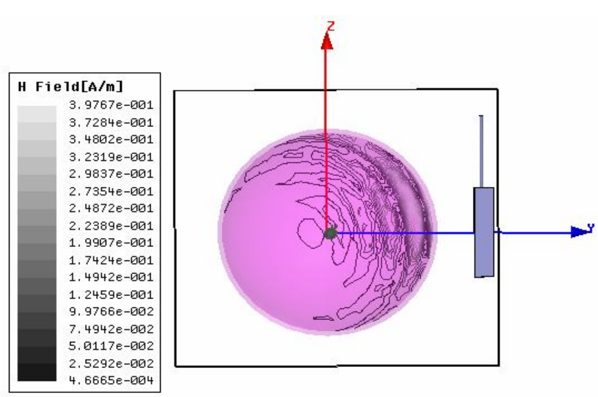

Fig5. Magnetic-field strength at 6cm.

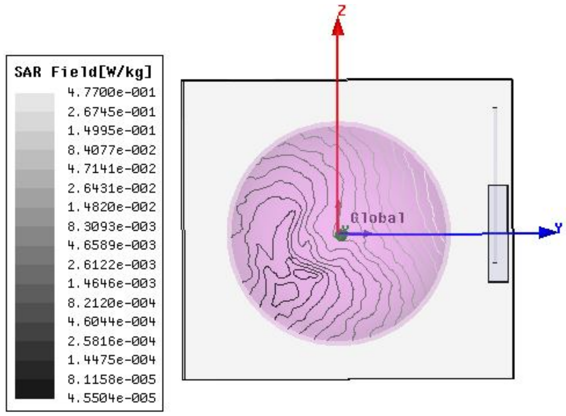

Fig6. SAR at 6cm.

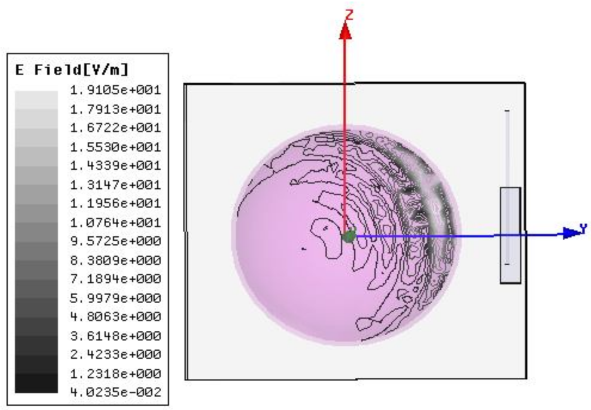

Fig7. Electric-field strength at 8cm.

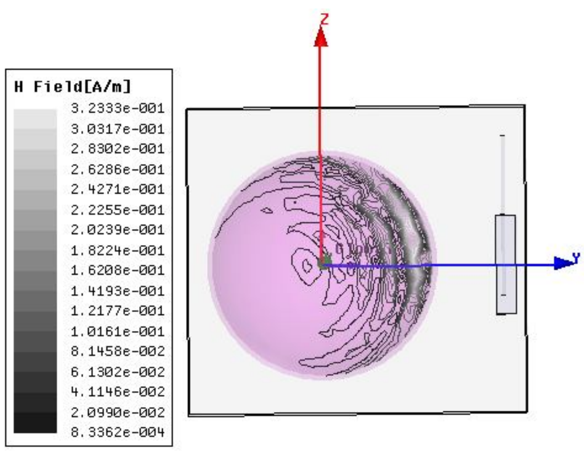

Fig8. Magnetic-field strength at 8cm.

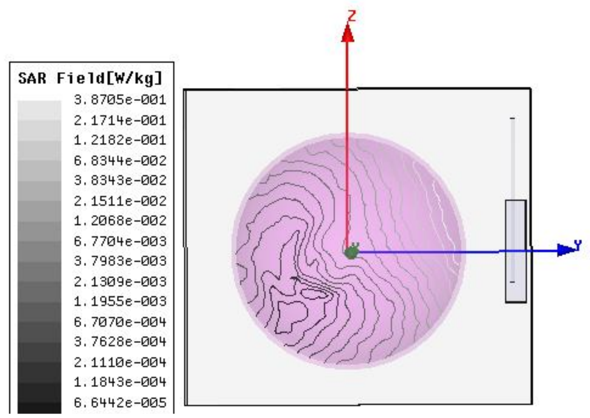

Fig9. SAR at 8cm.

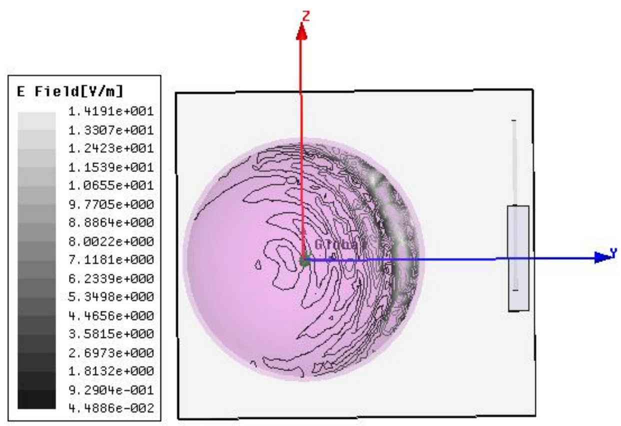

Fig10. Electric-field strength at 10cm.

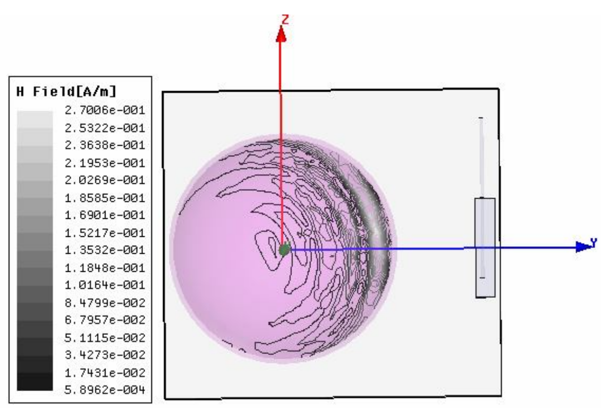

Fig11. Magnetic-field strength at 10cm.

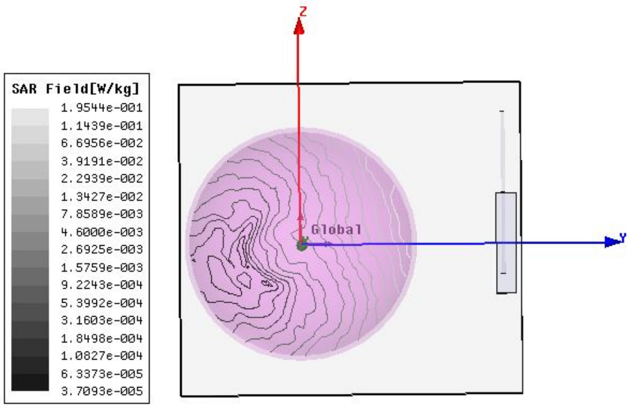

Fig12. SAR at 10cm.

The results from these figures show that the SAR, electric and magnetic field strength distributions are decreased by increasing the distance from exposure source. The peak of SAR, E-field and H-field are shown in Table.1. Also Fig.13, 14, and 15 show the comparison between distances 6, 8 and 10 cm.

Table.1: Comparison among the distances 6,8 and 10cm from exposure source.

Distance from antenna	E-Field(V/m)	H-Field(H/m)	SAR(Watt/kg)
6cm	19.6	0.391	0.477
8cm	19.1	0.323	0.387
10cm	14.1	0.270	0.195

Also Fig.11,12, and 13 show the comparison between distances 6,8 and 10 cm.

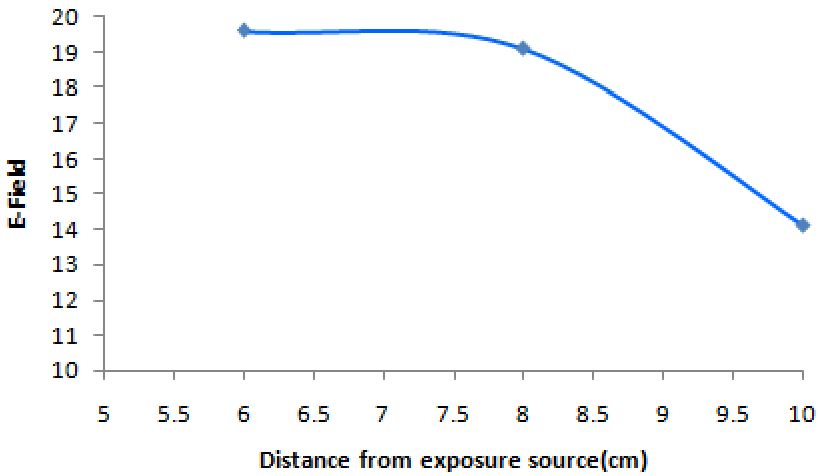

Fig13. E-field strength at 6cm, 8cm and 10cm.

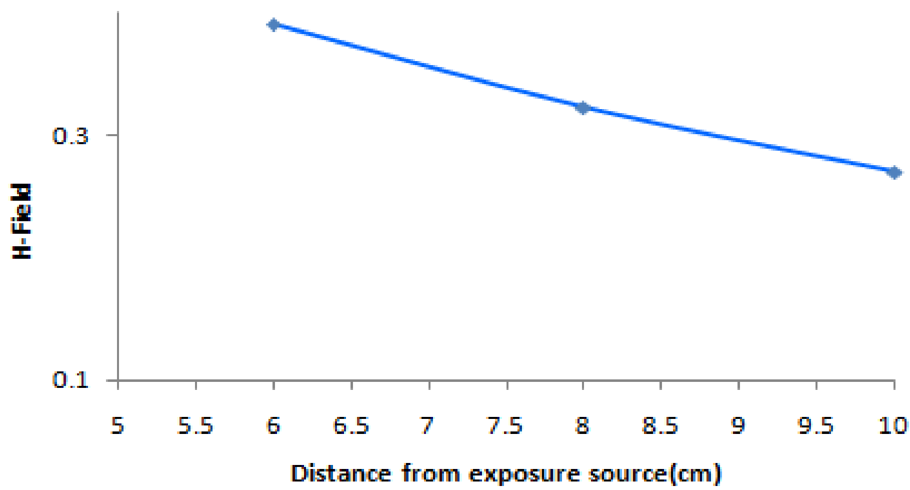

Fig14. H-field strength at 6cm, 8cm and 10cm

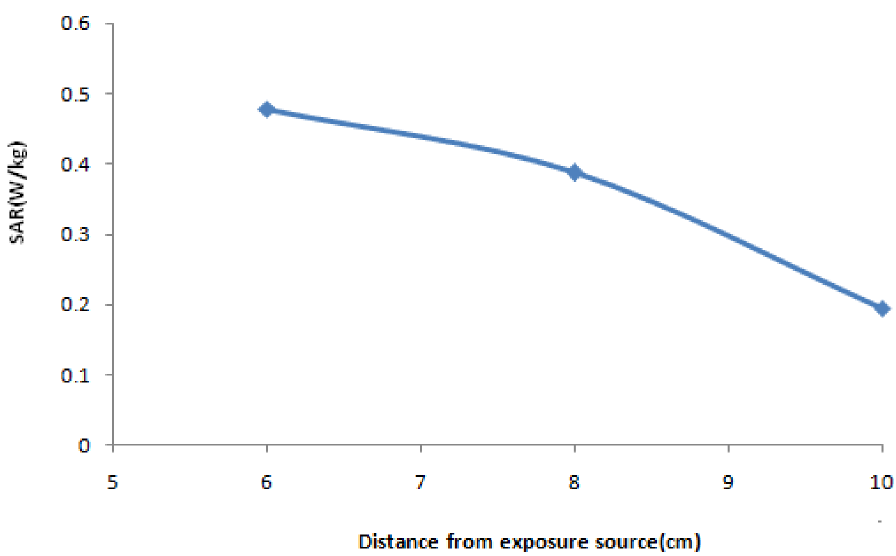

Fig15. The SAR at 6cm, 8cm and 10cm

CONCLUSION

The results show that the distance from exposure source is important and by increasing the distance the SAR decreases. Consequently, hands free use of cell phones may be advisable, because it keeps the cellphone further away from the head.

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