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Specific Absorption Rate (SAR) Assessment and Measurement of Temperature Change On Human Head Due To Radiations by Mobile Phone Antenna

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Abstract: Development of mobile phone communication infrastructure in the world has promoted which lead public concern over possible health effect exposure to radio frequency electromagnetic energy (RFEME) emanating from mobile phone antenna. The Micro-strip patch antenna plays an important role in electromagnetic energy transmitting and receiving phenomena in mobile phone. This paper makes an effort to assess the mobile radiation exposure effect on 4 years child, 8 years child and an adult head model. Hand held device model having micro strip antenna is used for human interaction. The software simulation performed by Computer simulation technique(CST) software based on Finite difference Time Domain technique yields specific absorption rate and 3D-thermal distribution on spherical human head.

Keywords: Finite Difference Time Domain (FDTD); Specific Absorption Rate (SAR); Electro Magnetic (EM) radiation.

INTRODUCTION

Now-a-days the world without mobile phones are unimaginable because of rapid growth of mobile application. Hence the mobile usage level is also increased There has been substantial research need to determine the radiation effects on human body. These behaviors are motivated by two factors: the need to evaluate the antenna performance in the presence of a human body, and the need to evaluate the rate of radio frequency (RF) energy declaration in the biological tissue, called specific absorption rates (SAR), in order to assess possible health effects and compliance with various RF exposure standards.

To ensure public safety concerning electromagnetic radiation exposure, the International Commission of Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE) have established guidelines and standard for limiting electromagnetic fields exposure. These guidelines and standard define basic restrictions, which specify SAR limits not to be exceeded. In INDIA the value of SAR should not exceed 1.6 W/kg beyond this limit is not permitted. The electrical property of the human body is changed like conductivity and permeability when human are affected by the electromagnetic field , some phenomena of the electromagnetic field like attenuation, diffraction, dispersion, reflection also occurs. But, to measure those phenomena inside the human body is quite difficult.

When the human body tissues absorb the radiation of the electromagnetic wave the temperature will increase because EM(electromagnetic) energy increase kinetic energy of the absorbing molecules. The electromagnetic energy absorb by the tissue will produce temperature that dependence on the cooling mechanism of the body tissue. When the thermoregulatory capability of the system is exceed, tissue damage result will occur. while placing mobile phone nearer to head for interaction, the emitted EM radiation gets coupled to human head tissues, which change the functions of cell. Even, we can also sense the temperature increment in outer panel of handset as well as ear, where handsets are pressed while talking for longer hours.

Due to increasing power, thetemperature is increased in human tissues. However, the sensed heat gets eventually decreased to equilibrium due to blood circulation. Permanent cell damage may be occur due to over usage of mobile phone when interacting with the human body. Areas with less efficient cooling by the circulation, e.g. the lens of the eye, brain cells are more sensitive to electromagnetic radiation. Since, the usage of mobile phones is unavoidable in this modern technological world, and the radiation exposure from mobile phone is non uniform ,to limit the radiation effect Specific Absorption Rate (SAR) is introduced with an averaging mass of 1 g and 10 g of tissue in the shape of cube. The analysis of power absorbed by the human head and the antenna performance are necessary for the compliance testing of mobile phones performance. This coupled field can be efficiently calculated by numerical method based on finite difference time domain technique.

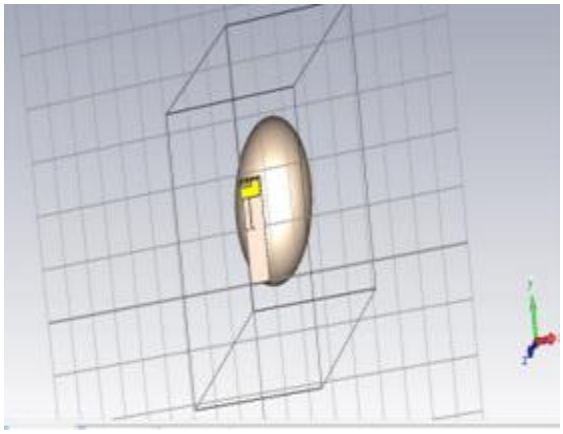

Figure 1 Micro strip antenna with human head model consists of brain, skin and skull

This paper endeavor to assess the health hazards, particularly the power absorbed by human head tissues and thermal effects due to exploitation of mobile phones. The work includes evaluation of specific absorption rate for children and adult with same electromagnetic environment. Results might enlighten the mobile phone users regarding radiation exposure effect from mobile phones and, ultimately results in the minimization of an individual's risks. Section Model development includes development of mobile phone antenna model (micro strip patch antenna),human head model (consists of brain, skin and skull). Measurement of power absorbed gives description about measurement of SAR and heat induced when mobile is nearer to the human head model.

MODEL DEVELOPMENT

A. Antenna model

In this paper , Micro strip patch antenna is used with single excitation port is placed in free space .The length of the patch antenna is 95mm for operating frequency range of 0.5-3GHz .

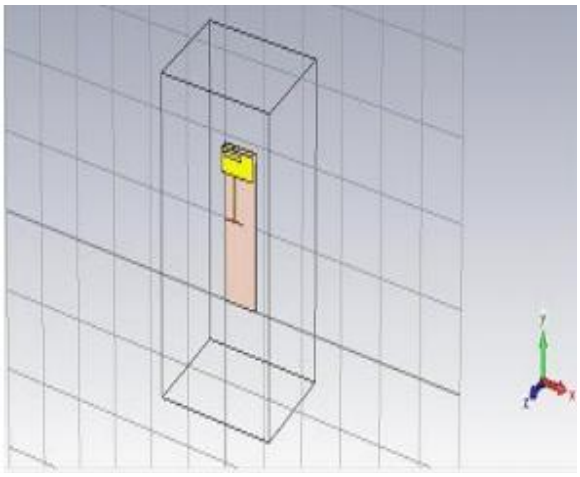

Figure 2 Micro strip patch antenna

The material used for microstrip-patch antenna is copper (annealed) . The lumped port excitation with 50 ohm internal resistance is located in the feed gap. Maximum working frequency of 3GHz is specified for excitation source. Antenna performance was analyzed in section conclusion by considering the parameters such as, the current distribution, Sparameter, starting with these initial requirements, we optimized the design through simulation using CST software package based on the Finite Difference Time-Domain technique. For analyzing SAR and thermal distributions, the near field environment may include a human head and antenna enclosed by a plastic frame , which may influence on antenna performance.

B. User head model

The user's head (4 years child, 8 years child and adult) was modeled as a sphere with three layer such as skin, skull and brain , using CST software. Human body tissues have different values of dielectric properties that is, permittivity and conductivity and these properties are the function of several variables such as frequency, geometry and size of tissue, and water contents.

C. Hand held device model

A handheld device model used for human interaction has modeled by CST. Figure1)shows the interaction of handheld geometric model which has a maximum dimension 167mm *23mm*83mm with spherical human head. Components considered for simulation are feeding port (patch antenna), plastic cover (ε=4.4) and plastic cover was modeled as dielectric materials.

Measurement of power absorbed

A. Specific absorption rate (SAR)

SAR is a measure of the rate at which energy is absorbed by the body when exposed to a RF electromagnetic field. It is defined as the power absorbed per mass of tissue and has units of watts per kilogram (W/kg). SAR is usually averaged over a small sample volume (typically 1 g or 10 g of tissue).

$$SAR= (\sigma E^2)/2\rho$$

Where, E is the effective value of the electric field intensity (V/m) in tissue, ρ is the tissue density (kg/m^3) and σ is the conductivity of the material(s/m).

The unit of specific absorption rate is W/kg. Due to evolution in wireless technologies, dosimetric evaluation of handheld device is highly desirable for safety environment. For radio frequency signals, SAR value is calculated for either 1g (Australia, United States) or 10g

(Europe, Japan) of simulated biological tissue in the shape of a cube. In india the SAR value limited to 1.6 W/kg. The partial exposure SAR limit recommended by the council of theEuropean Union.

SAR is used to measure exposure to fields between 100 kHz and10 GHz. It is commonly used to measure power absorbed from mobile phones and during magnetic resonance imaging (MRI) scans. The value will depend heavily on the geometry of the part of the body that is
exposed to the RF energy and on the exact location and geometry of the RF source. For example, head in a talk position. The SAR value is then measured at the location that has the highest absorption rate in the entire head, which in the case of a mobile phone is often as close to the phone's antenna as possible.

Tissues are made up of water content, different salts and organic compounds and they can be considered as a mixture of insulators and conductors. Brain tissue is rich in water along with fat content and cerebrospinal fluid along the ventricles and extends to flow along spinal cord. When a portable cellular telephone is in the typical use position, the nearest brain tissue is in matter of relatively uniform dielectric characteristics with macroscopic values of dielectric constant and conductivity ε_r = 52.7 and σ = 0.94 S/m in the frequency band of interest.SAR value for different age group
peoples ie) 4years child, 8years child and an adult, using computer simulation
technology(CST)

Figure 3) Head in a talk position to measure SAR value.

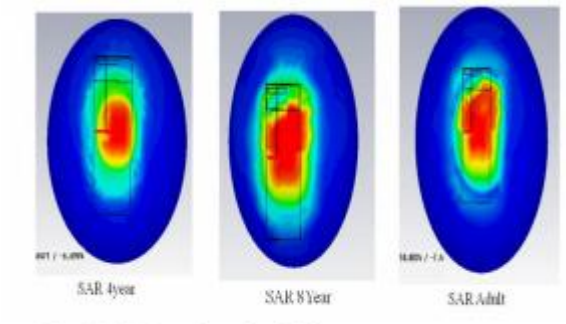

Fig 4) SAR value for different age group

B. Theoretical calculation

SAR is amount of radiation which is absorbed by the human tissues while using the cell phones. When the SAR rate is very high it represents the radiation absorbed is also veryhigh. This SAR value is usually measured in units of watts per kilogram (W/kg) in either 1 or 10 gram of tissue.

SAR=(σE^2)/2ρ

Where, E is the induced electric field strength(V/m) in tissue,ρis the tissue density (kg/m^3),σis the conductivity of the material.The skin induced electric field can be calculated to be 17.983V/m. Therefore, the SAR in head skin can be calculated.

SAR=σE^2/2ρ
=1.25*(17.982)^2/2*1010
=0.2000942 W/kg.

The induced electric field for skull can be calculated to be 22.069V/m. Therefore, the SAR in head skull can be calculated.

SAR=0.45*(22.069)^2/2*1810=0.06054 W/kg.

The Brain induced electric field can be calculated to be 6.96V/m and the SAR is determined as:
SAR=1.29*(6.96)^2/2*1040=0.030043 W/kg.

Table1: calculated SAR value

Tissue	**Conductivity** (S/m)	**E**(V/m)	**Density** (kg/m^3)	**SAR** (W/kg)
Skin	1.25	17.982	1010	0.200
Skull	0.45	22.069	1810	0.060
Brain	1.29	6.96	1040	0.030

C. Thermal Effects

Thermal effects are due to rise in temperature produced by the energy absorbed from oscillating electric fields emitted by mobile phone antennas

.The dark red color shows higher temperature near antenna feeding point and get varies along the length of the case. Similarly, the current generated in brain tissue which varies temperature.

The lens of eye may experience a temperature increase of 1°C at SAR level of 10 W/kg. At cell level the heating cause damage by disturbing the functioning of proteins. Cells begin to die when the temperature rises more than 5°C,but the tissues can endure momentary increase of tens of degree.

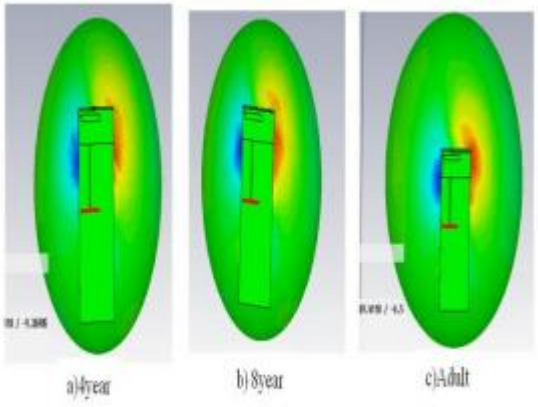

Fig 5) Thermal distribution

Evaluation of antenna in free space

A. Current distribution and S-parameters

Computer simulation technology are used to generate animations of the electric surface currents with feeding port excited. Feeding port is used to generate power supply for patch antenna. Current distribution is different for 4 years child , 8 years child and adult, which dependents upon the water content this differs from people to people. The excitation of the port induces high-magnitude surface currents in the proximity of each feed, but a null-current area is clearly shown to exist at the open circuit end. The simulated S-parameter of the patch antenna is shown in above figure.

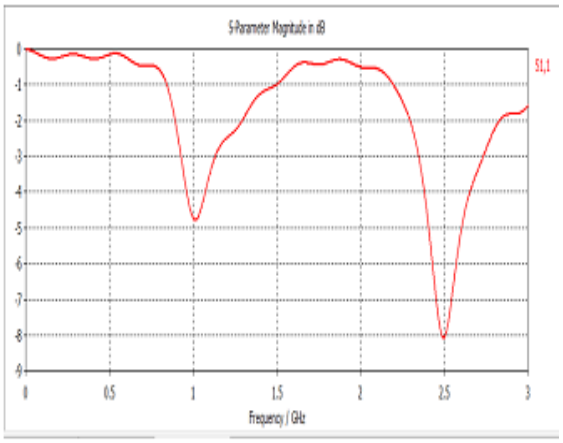

Fig 6) S-parameters for patch antenna port [simulation results shows good return loss which suitable for mobile communication].

B. Radiation pattern and efficiency

The simulated 3-D gain pattern for patch antenna is shown in fig7, for the operating frequency of 3GHz. The total efficiency of an antenna is defined as the ratio of total radiated power to the incident power at the feed. The original radiated pattern of patch antenna get altered due to human head interaction.

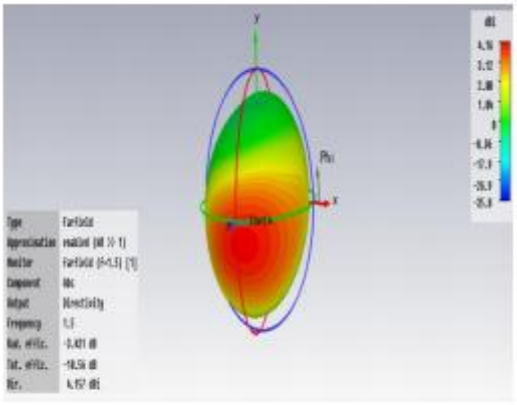

Fig7) Radiation pattern of patch antenna. [simulated result of radiation pattern of patch antenna]

C. Mobile phone interaction with head model SAR analysis

The spherical human head composed of three inner layers is simulated and is allowed to interact with the mobile phone placed very near to ear.

Table: comparison of 1g and 10g tissue SAR value

Model	4years child	8years child	Adult
1g SAR(W/kg)	3.83402	1.8639	1.82617
10g SAR(W/kg)	0.89609	0.772787	0.742898

The value of SAR averaged over 1g and 10g tissues of human head have been computed, when mobile phone placed near human head and are listed in table. The power absorption level of each layer differs due to its thickness, water content, conductivity and permittivity. Current distribution and 3D thermal distribution in head is shown in figure.From the results obtained using CST software, the SAR values are higher for children.

Conclusion

From the studies and above results, it is concluded that, the power absorbed by children head is higher than adult. It might be due to variation in the head tissue layer thickness, which is lower in case of children. Since, the skull bone of adult is very thick comparatively; the intensity of power coupled to the brain is lesser.

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