SPECIFIC ABSORPTION RATE ASSESSMENT 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, 8years 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.

Index terms: Radio Frequency ElectroMagnetic Energy (RFEME) , Computer Simulation Technique (CST),Specific Absorption Rate (SAR),Magnetic Resonance Imaging (MRI)

I. INTRODUCTION

With the growth of recent use and estimated supplementary increases in the use of mobile phones and other private communication services, there has been substantial research effort dedicated to the interaction between antennas on handsets and the human body. To ensure public safety concerning radiofrequency 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. When human are affected by the electromagnetic field ,the electrical property of the human body is changed like conductivity and permeability and 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[1,2]. When the tissue of the human body absorb the radiation of the electromagnetic wave then the temperature of the human body tissue 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, the emitted EM radiation gets coupled to human head tissues, which might alter the basic biological function of cells. Even, we can sense the temperature increment in outer case of handset as well as ear, where handsets are pressed while talking for longer hours shown in fig 1.

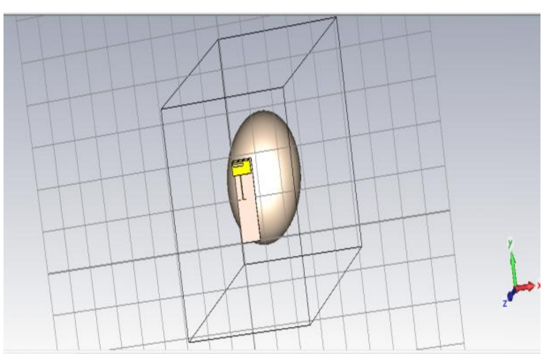


Fig: 1 Micro strip antenna with human head model consists of brain, skin and skull.

The temperature increment in human tissue is due to power coupled and it may vary with interacting environment. However, the sensed heat gets eventually decreased to equilibrium due to blood circulation. The consequences of excessive heating in the body vary from temporary disturbances in cell functions to permanent destruction of tissues. Areas with less efficient cooling by the circulation, e.g. the lens of the eye, brain cells are more susceptible to electromagnetic radiation[3,4]. Since, the usage of mobile phones is inevitable in this modern technological world, and the radiation exposure from mobile phone is non uniform, limits can be précised in terms of Specific Absorption Rate (SAR) with an averaging mass of 1 g and 10 g of tissue in the shape of cube. Further, heat induced in tissues signifies the well known adverse health effect at microwave frequencies.The analysis of power absorbed by the human head and the antenna performance are necessary for the compliance testing of mobile phones performance[7,8,9]. This coupled field can be efficiently calculated by numerical method based on finite difference time domain technique. This work endeavor to assess the health hazards, particularly the power absorbed by 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. Antennas are essential components of all equipment that uses radio. They are used in systems such as radio broadcasting, broadcast television, two-way radio, communications receiver radar, cell phones, and satellite communications, as well as other devices such as garage door openers, wireless microphones, Bluetooth-enabled devices, wireless computer networks, baby monitors, and RFID tags on merchandise [5,6].

II. PROPOSED SYSTEM

In the proposed system, micro strip antenna is designed using computer simulation software with finite difference time domain technique. Now a day's mobile phones are designed with printed circuit boards, hence we designed the micro-strip antenna for the human head interaction calculation of SAR value (specific absorption rate). The frequency range of micro-strip antenna is 0.5-3GHz. Mobile phone handsets are used by people of various age group and we make an effort to assess the mobile phone radiation exposure effect shown in fig2.

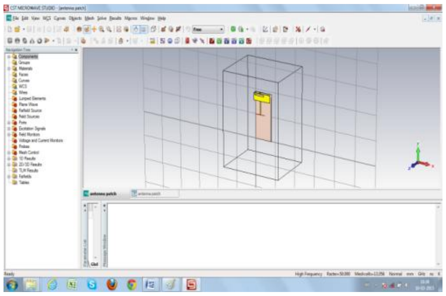


Fig:2 Micro-strip patch antenna design

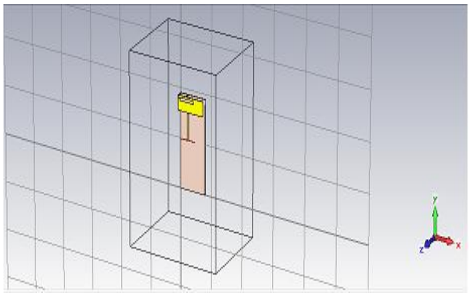


Fig 3. Micro strip patch antenna

Model development includes development of antenna model (micro strip patch antenna), Human head model (consists of brain, skin and skull) and Hand held device model.

III. ANTENNA MODEL:

In this work, 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

In the design of micro-strip antenna, there are six different steps involved in the process using CST STUDIO SUITE in that we have to select a template depending upon application; here we are selecting Antenna (mobile phone) shown in fig3.

Step1: The solid 1 (Ground plane) is implemented, the length of ground plane is 95mm and the material used for this is copper (annealed). In the printed circuit boards, a ground plane is a large area of copper foil on the board which is connected to the power supply ground terminal and serves as a return path for current from different components on the board.

Step2: Solid 2 is for mobile phone cover, the length is same as ground plane and the material used here is FR-4 (lossy).FR-4(lossy) is selected because of its low cost.

Step3: Solid3 is implemented for main substrate cover (i.e, patch antenna cover) . The length of the main substrate cover is 15mm and material is used same as mobile phone cover.

Step4: Solid4 represents the patch antenna which is Z orientation. The length of the antenna is 0.07mm and different dimensions are given in the X and Y direction. The shape that is used for patch antenna is brick from extrude. The material used in the soild4 is copper (annealed).

Step5: Solid5 is short pin which is used to connect the ground plane with patch antenna. Here also the material is copper annealed.

Step6: Solid6 and solid7 are used for feed pin, which is used for the input power to the antenna. The material 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, S-parameter, 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.

IV. HUMAN HEAD MODEL:

Table1. Properties of tissues in human model

Tissue	**Brain diameter(mm)**	**Skull thickness(mm)**	**Skin thickness(mm)**
4 years child	136.1	3.1	3.6

8 years child	140.6	3.5	4
Adult	160.1	8.9	7.2
Permittivity	52.7	12.5	35.2n
Conductivity	0.94	0.14	0.60

The user's head (4 years child, 8 years child and adult) was modeled as a sphere with three layers 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 shown in table 1.

V. HUMAN HEAD DEVICE MODEL:

Hand held device model

A handheld device model used for human interaction was modeled by CST. Figure 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 (eε =4.4) and plastic cover was modeled as dielectric materials.

VI. MEASUREMENT OF POWER ABSORBED

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 either over the whole body, or over a small sample volume (typically 1 g or 10 g of tissue).

SAR= (σ(E) ^2)/ (2ρ)----------------------(1)

Where, E is the effective value of the electric field intensity (V/m),

$\sigma$is the electric conductivity (S/m),$\rho$is the mass density(Kg/m3) and

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. Partial (localized) non occupational exposure is limited to a spatial peak value not exceeding 1.6 W/kg. The partial exposure SAR limit recommended by the council of the European Union and adopted by India is also 1.6 W/kg.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, 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 $\varepsilon r = 52.7$ and $\sigma = 0.94$ S/m in the frequency band of interest shown in fig 4.

Figure: 4. Head in a talk position to measure SAR value.

VII. THEORITICAL CALCLATION:

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 very high. This SAR value is usually measured in units of watts per kilogram (W/kg) in either 1 or 10 gram of tissue shown in table 2.

SAR= (σE^2)/2ρ--------------------------------------(2)

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.-----------(3)

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-----------------(4)

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.---------------------(5)

Tables: 2.calculated SAR value

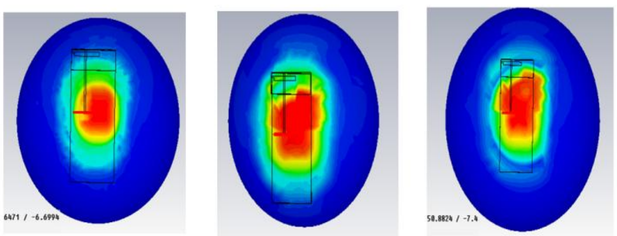
Tissue	**Conductivity**(S/m)	**E**(V/m)	**Density** (kg/m^3)	**SAR**(W/kg)
Skin	1.25	17.982	1010	0.200
Skull	0.45	22.069	1810	0.060
Brain	1.29	6.96	1040	0.030

SAR value for different age group peoples

1)4years child

2)8years child

3) Adult, using computer simulation technology (CST)



SAR 4year SAR 8 Year SAR Adult

Fig.5.SAR values of different age group peoples

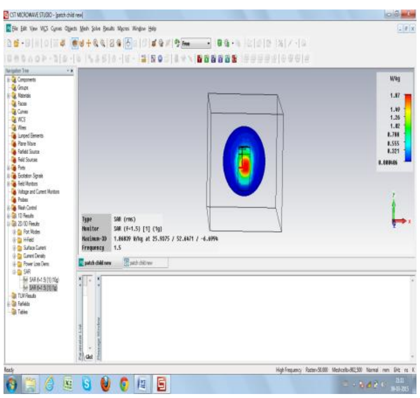


Fig.6. SAR- 4year child

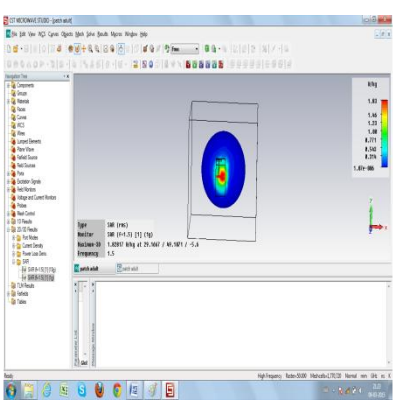


Fig.7. SAR -8year child

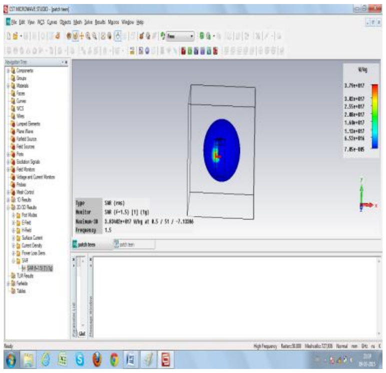


Fig.8. SAR-adult

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 power coupled causes the temperature to rise until, this induced heat reaches stable equilibrium value through blood circulation along the body which will take several minutes from the moment RF exposure occurs. Generally, thermal energy is dissipated from the body by sweating and increased peripheral circulation. The consequences of excessive heating in the body vary from temporary disturbances in cell functions to permanent destruction of tissues. 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 degrees shown in fig6,7,&8.

Thermal distribution for different age group peoples

1)4years child 2)8years child 3) Adult, using computer simulation technology (CST)

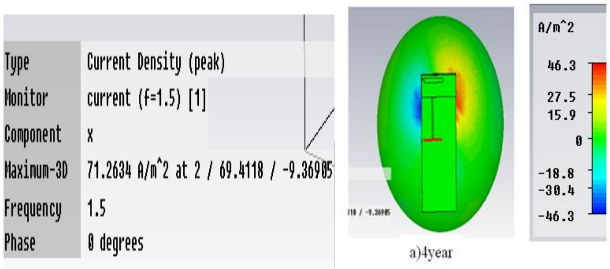


Fig9: 4YEAR CHILD

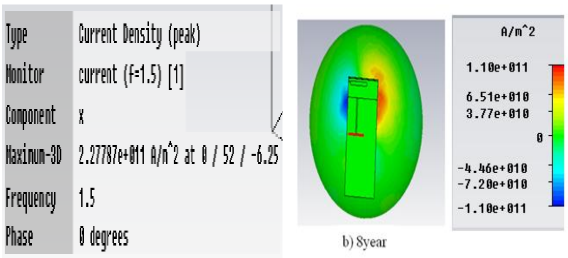


Fig10: 8YEAR CHILD

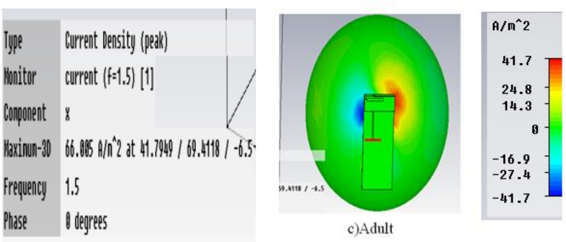


Fig11: ADULT

Computer simulation technology is 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 depends 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(9-11)

VIII. EXPERMENTAL RESULTS

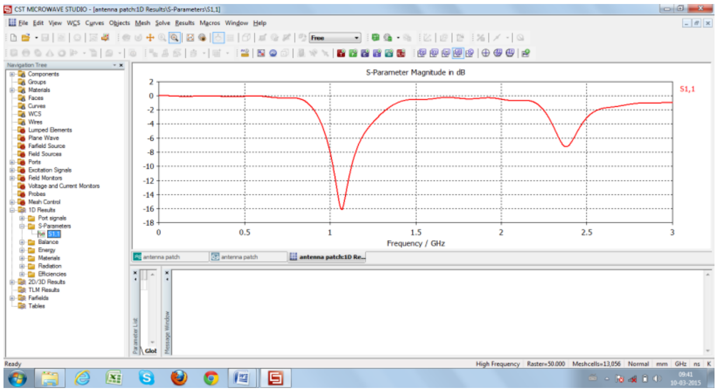


Figure: 12. S-parameters for patch antenna port [simulation results shows good return loss which suitable for mobile communication].

The result (Fig 12)indicates that, for frequency band of interest (0.5-3GHz), feeding port provides a better return loss suitable for wireless communication applications.The simulated 3-D gain pattern for patch antenna, 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 gets altered due to human head interaction shown in fig13,14..

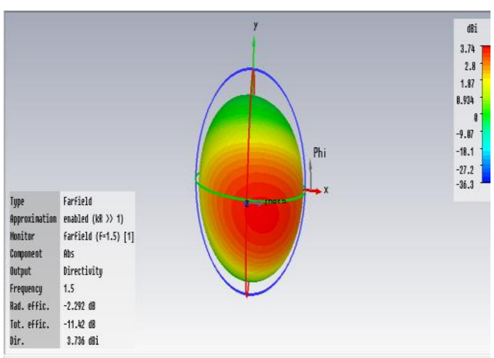


Figure13.Radiation pattern of patch antenna [simulated result of radiation pattern of patchantenna]

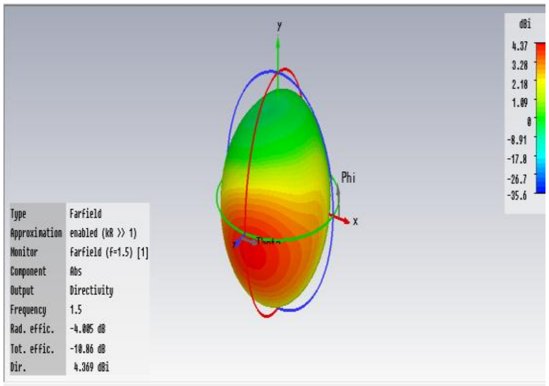


Figure: 14. Radiation pattern of patch antenna with human head interaction

IX. Mobile phone interaction with head modelSAR analysis

The spherical human head composed of three layers is simulated and is allowed to interact with the mobile phone placed very near to ear shown in fig 15.

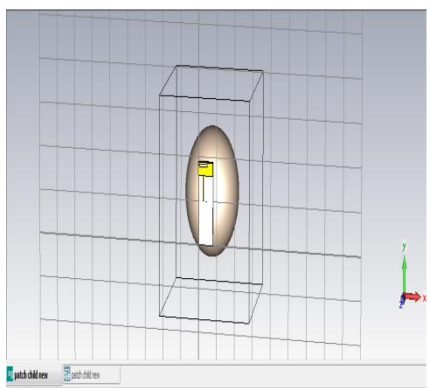


Fig.15. Mobile patch antenna interaction with head model

Table: 3.comparison of 1g and 10g tissue

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 table3. 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 figure16-19.. From the results obtained using CST software, the SAR values are higher for children.

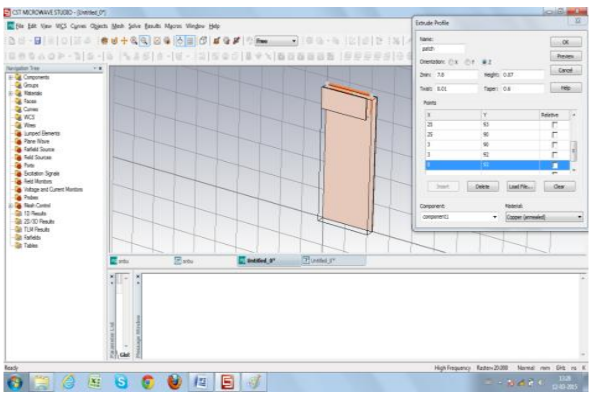


Fig: 16. Micro strip antenna with initial requirements

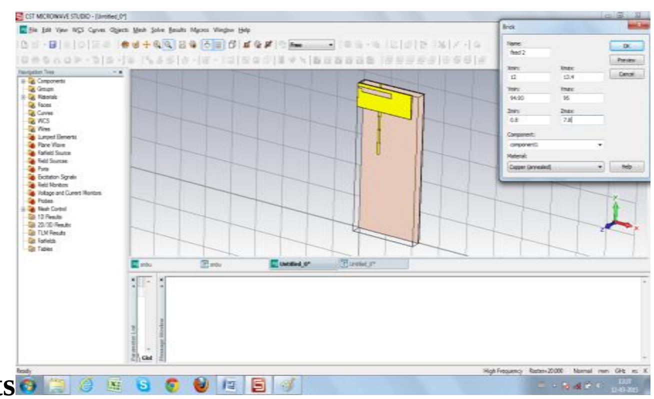


Fig: 17. Fully designed micro strip antenna

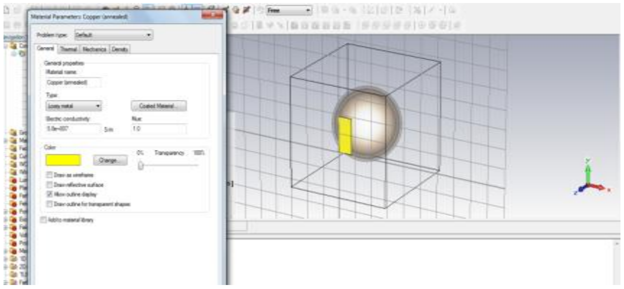


Fig: 18. Head model interaction with micro strip antenna

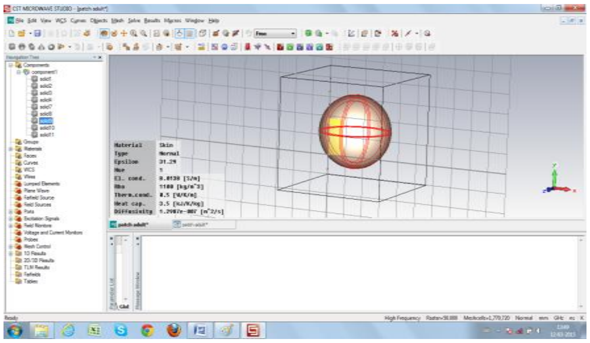


Fig: 19. Human head model with three layers

X. 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.The proposed system can be further developed to decrease its power coupled. The resistive sheet of 50ohm is placed on the user front side of mobile phone handset case. This method shows maximum of 50% decrement in the power coupled.

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