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PEAK SAR REDUCTION IN HUMAN HEAD USING METAMATERIAL STRUCTURE

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ABSTRACT
The purpose of this paper is to calculate the reduction of Specific absorption rate(SAR) using metamaterial attached to reactangular microstrip patch antenna operating at GSM 900 MHz. The FDTD method with lossy Drude model is adopted in this analysis by using CST Microwave studio. The SAR in the head can be reduced by placing metamaterial between human head and antenna used.Here we have used RMPA with metamaterial substrate upon it.Using this, we have achieved a 97.99% reduction in case of 1g SAR and a 98.02% reduction for the case of 10g SAR.These results are useful in designing of safety communication equipments having low values of SAR.

KEYWORDS: FDTD method, head model, metamaterials, specific absorption rate (SAR).

INTRODUCTION
With the proliferation of cell phones, wireless internet and personal electronic devices, the ill effects of electromagnetic radiations are of huge concern. There are various known negative health effects of these radiation which include hypersensitivity to radiations, potential link to certain cancers, reducing the efficacy of certain drugs and many more. The mostly used gadget in our daily life is our mobile phone. Mobile phone uses various types of antenna. Here I have used a microstrip antenna .They are mostly used at microwave frequencies. Our mobile phone emitts electromagnetic radiations in all directions which can cause a harmful effect on our body. We use a term SAR (specific absorption rate) for evaluating electromagnetic energy in human tissue.

SAR is a measure of the rate at which energy is absorbed by human body when exposed to radio frequency electromagnetic radiations . It is defined as the power absorbed per unit of tissue in watts per kilogram(W/Kg).

SAR is usually averaged either over the whole body,or over a small sample volume(typically 1g or 10g of tissue).The value cited is maximum level measured in the body part studied over the stated volume/mass.

It is the time derivative(rate) of the incremental energy (dW) absorbed by or dissipated in an incremental mass (dm) contained in avolume element (dV) of a given density (ρ) in equation 1 [2].

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho dm}\right) \qquad (1)$$

The SAR is expressed in units of watts per kilogram(W/kg) or, equivalently, in milliwatts per gram (mW/g). It can also be related to the induced electrical field using equation 2 [2].

$$SAR = {}^{\sigma E^2}/_{\rho} \qquad (2)$$

Where, E is the electric field's root mean square (V/m), σ is the biological tissue's electrical conductivity (S/m)and ρ is the biological tissue's density (kg/m3).

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As per the international safety guidelines [3,4] the SAR must be below the limits. Some results have implied that the peak 1*g* averaged SAR value may exceed the safety limits when a mobile telephone is placed extremely close to the head.For reduction of SAR, a metamaterial is used.

Metamaterials are artificially structured materials used to control and manipulate many physical phenomena. There properties are derived from the inherent properties of their constituent materials as well as from their geometrical arrangement.Two important parameters, electric permittivity and magnetic permeability determine the response of the material to the electromagnetic propagation.

The specific absorption rate (SAR) in the head can be reduced by placing the metamaterials between the antenna and the head. In the case of studying the SAR reduction of an antenna operating at the GSM 900 band, the metamaterial parameter (i.e., the permittivity is €r< 0,hence, the refractive index is $n < 0$) and the effective medium would be set negative [6-7]. Hence, the effectiveness of different positions, sizes, and metamaterials with various parameters are also analyzed for SAR reduction.

METAMATERIAL DESIGN USED FOR SAR REDUCTION

METHODOLOGY

Computer Simulation Technology Microwave Studio(CST MWS)is a device used as a major simulation instrument based on the finite-integral time-domain technique (FITD).

The head models used in this analysis were obtained from a magnetic resonance imaging (MRI) based head model through the whole brain Atlas website. Six types of tissues, i.e., bone, brain, muscle, eye ball, fat, and skin were involved in the model [8-9].

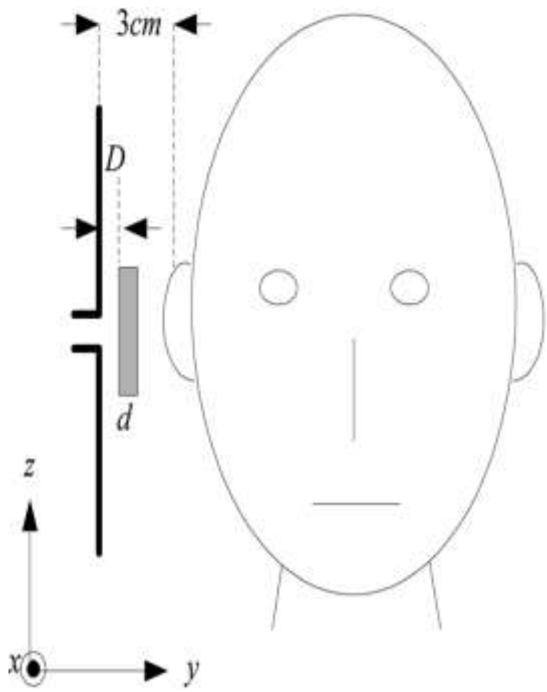

Fig. 1. The head and antenna models for SAR calculation.

Figure 1 shows a mobile phone model along with human head used for SAR calculation.
The proposed human head model for SAR calculation is as shown in Figure 2. It consists of four layers. The outermost layers in the human head is skin with thickness of 0.5cm, second layer represents the human fat with thickness of 0.5 cm, third layer represents the human bone with thickness of 0.5 cm and the inner layer is the human brain with radius of 7.25 cm. The electrical properties of skin, bone and brain are shown in Table 1.

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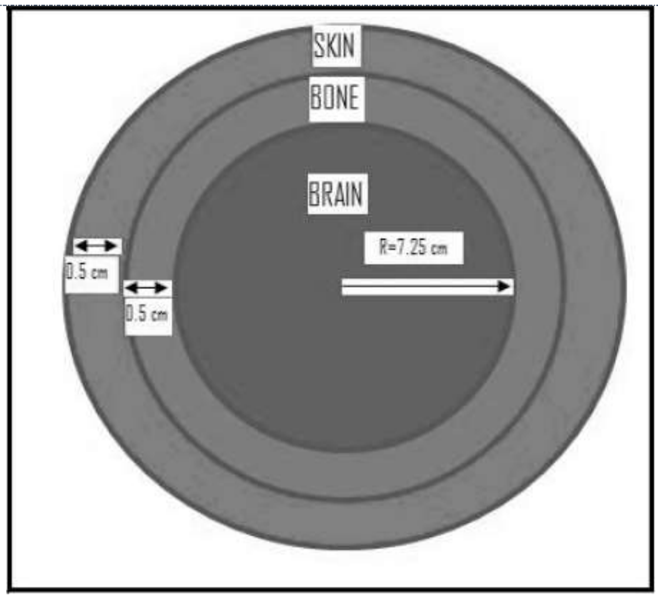

Figure 1: Layout of Human head model.

Table 1:Electrical properties of different components of human head model.

Material	**Density ‘ρ’, (kgm^{-3})**	**Conductivity ‘σ’, (Sm^{-1})**	**Relative permittivity, (€r)**
Skin	1100	8.013	31.29
Bone	1850	3.859	12.661
Fat	1100	0.585	4.6023
Brain	1030	10.31	38.11

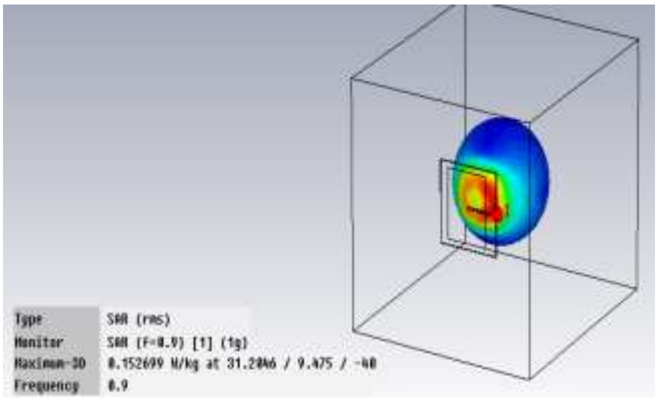

Fig 2. Human head model with attached RMPA without metamaterial

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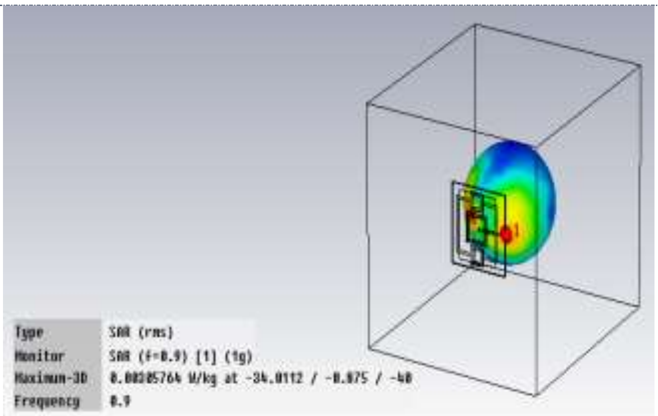

Figure 3. Human head model with attached RMPA with metamaterial.

In fig2, the human head model with attached RMPA without attached metamaterial is shown, also it shows evaluated 1g SAR which is 0.152699W/Kg. The fig 3 shown the same model but with metamaterial attached to antenna. In this case, 1g SAR is 0.00305764 W/Kg which shows the significant reduction in SAR value.
Similarly , the values are calculated for 10g of tissue.

RESULTS AND DISCUSSION

The proposed metamaterial with proposed human head model is designed and simulated using the CST Microwave Software [10]. Figure 4 shows the simulated return loss of the proposed design. The achieved simulated return loss of the proposed RMPA with attached metamaterial is -23.58dB at a frequency 0.89 GHz .

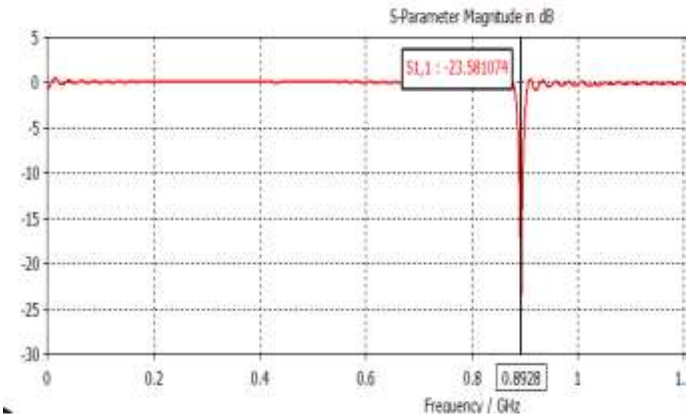

Figure 4: Simulated return loss of proposed metamaterial patch anntena with human head model at 0.89 GHz.

The 2D radiation patterns of proposed CSRRs with human head model at a frequency of 0.89 GHZ in polar plot is shown in figure 5.

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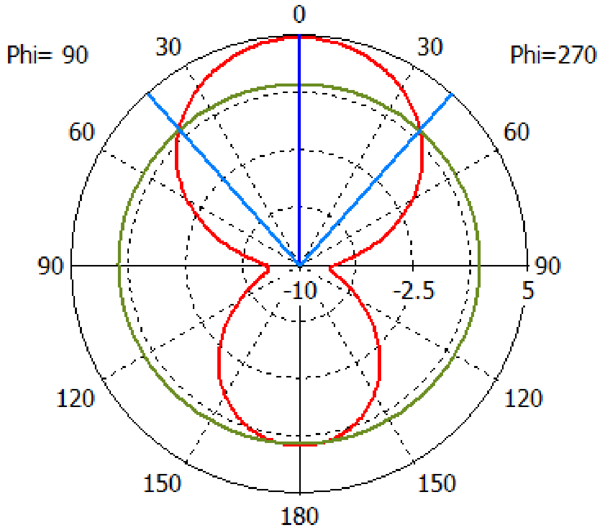

Figure 3: Simulated radiation pattern result of the proposed CSRRs with human head model at 0.904GHz.

The radiation efficiency and directivity at resonant frequency of 0.904 GHz are 79.23% and 4.873 dBi respectively.

An important feature of the proposed CSRRs with human head model is to reduce the level of SAR. The simulated peak SAR for 1 gm value is 0.024 W/kg, and SAR 10 gm value is 0.0125 W/kg when the CSRRs is placed 12.5 mm away from the proposed human head model.

Table 2 shows the simulated SAR values of the proposed CSRRs with human head model.It has also been observed that as the distance between the antenna and metamaterial substrate is increased, the SAR also increases.So, to achieve minimum SAR value, metamaterial substrate should be kept closer to antenna.

Table 2.Simulated SAR value in the human head for different mass of tissue.

SAR Value (watts/kg)	With metamaterial	Without Metamaterial	%reduction
1g	0.00305764	0.152699	97.9%
10g	0.00137327	0.0688161	98%

It is clear from the simulation results that metamaterials can reduce the peak SAR successfully where the antenna reduction is merely pretended.

CONCLUSION

The SAR distribution in a muscle tissue with and without the presence of metamaterial is evaluated. A significant reduction in SAR value is observed using metamaterial.This proves to be helpful for designing mobiles phones with low SAR values.Also,as the distance between microstrip patch antenna and metamaterial increases, the SAR value also increases which implies that the metamaterial substrate and patch antenna should have the minimum air gap between them.

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