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A Review on SAR Reduction Methods Used For Mobile Application

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Abstract: *This paper presents a study of different methods used for specific absorption rate (SAR) reduction and factors depending on the SAR value for mobile application. The presented studies provide useful information for future design of mobile handset antennas. The Size, position of the antenna, material used and some other parameters also decides SAR value. According to standardization regulation committee in different region SAR value should be maintained in any mobile phones. So that SAR value is a crucial point in antenna design.*

Key terms: *Specific Absorption Rate (SAR), Meta materials, SRRs, Compensation method.*

I. Introduction

Antennas are the connecting links between the transmitter and free space or free space and the receiver in a communication system. As the communication devices are becoming smaller the antenna becomes a important part of the device. For mobile communication small size is preferred. The new trends in antenna design mainly focuses on the compactness of antenna, its robustness and integration with the existing RF circuit components. The application of mobile phones and wireless communication technology increased exponentially. Today's world each and everyone use mobile devices that uses EM waves which is absorbs by human tissue. Because of the absorption of these EM waves damages the human tissue. So it is necessary to decrease the interaction of electromagnetic energy towards human head from mobile handset when in use. The measurement of absorption of EM waves by the human tissue is known as the specific absorption rate (SAR). Therefore it is necessary to concerns about the safety aspects and hazardous effect of EM waves. For the design of antenna SAR value is important. There are some factors which will influences SAR value like size, position, radiated power and type of antenna used etc.

II. Specific Absorption Rate (SAR)

The specific absorption rate (SAR) is defines as the measure of how much transmitted EM energy is absorbed by human tissue.

$$\mathrm{SAR} = \int \frac{\sigma(r)|E(r)|^2}{\rho(r)}\,dr \quad \text{----------------} \ (1)$$

The calculation is done over a specific volume. SAR is a function of the electrical conductivity (σ) is measured in Siemens/meter and the induced E-field from the radiated energy is measured in Volts/meter, and the mass density of the tissue (ρ) is measured in kg/cubic-meter. The SAR is calculated by averaging or integrating over a specific volume. The units of SAR are W/kg.

The SAR limit is different in different regions and it is based on the standardization committee. In the US for mobile phones is 1.6 W/kg, averaged over 1 gram of tissue. But in Europe, the SAR limit is 2.0 W/kg averaged over 10 grams of tissue. India has adopted the most stringent FCC norms for mobile handsets“ From 1st Sept. 2013, only the mobile handsets with revised SAR value of 1.6 W/kg would be permitted to be manufactured or imported in India ”. If the SAR value is too high the antenna must be changed and also the transmit power is lowered, which directly yields lower SAR. The SAR cannot be dropped indefinitely, since there are minimum transmit power specifications for mobile devices. The positioning of antenna is important to the point of view of SAR. The antennas for mobile phones are typically on the bottom of the phone, to keep the radiating part of the phone as far as possible from the brain region. Therefore methods for dropping the SAR include impedance matching changes and parasitic resonators which will disturb the antenna's radiation pattern.

III. Methods used to SAR reduction

There are different methods to reduce radiation towards the user from handsets are introduced. Most of the studies focus to reduce the absorption towards the head. So that in all these method first we will create head model made up of multiple layers by considering all the properties human head. Then simulation is done using different simulation software's like HFSS, CST Microwave Studio, etc. Commonly used methods used to reduce the absorption of EM waves are described below.

1. Adding an RF shield to mobile phones -The RF shields [3-5] are used for the reduction of unnecessary radiations. The RF shield is placed at the front side of the phone. The selection and placement of the shield are the important factors. Mostly ferrimagnetic materials are used. The ferrite material is used because the conductivity is low which results in much smaller induced currents in the material when electromagnetic waves are applied. Also when an electromagnetic wave hits ferrite particles, the magnetic field part of the wave is canceled. The mechanism behind this method is it will suppress the surface current on the front side. The effectiveness of RF shielding can be defined by a factor called SAR Reduction Factor (SRF), it is defined as [4]

$$\mathrm{SRF1g}\ (\%) = \frac{(\mathrm{SAR\ 1g} - \mathrm{SAR\ 1g,s})}{\mathrm{SAR\ 1g}} * 100 \text{ -------------- } (2)$$

where (SAR_{1g}) is 1g peak SAR without Rf shield and the ($SAR_{1g,s}$) is the 1g peak SAR with RF shield. (SRF_{1g}) is the SRF for 1g peak SAR.

The SAR reduction can be done in four different ways [3] based on Location of RF Shield, based on size of RF Shield , based on shape of RF Shield, based on thickness of RF Shield. The study on the RF shielding does not degrade the antenna performance. However there is slight variation in return losses when compared with RF shielding. So the RF shielding gives an option for compliance testing of mobile phones at the design stage.

2. Usage of highly directive antennas – The antenna used inside a mobile can replace by highly directive antenna[6]. It will also help to reduce radiation towards human head, but, the adoption of highly directive antennas certainly causes degradation in signal reception from other directions.

3. **Array of Split Ring Resonators (SRRs) -**The split ring resonators [7] are placed between the antenna and human head. Arranging the split ring resonators (SRRs) periodically it will be a meta material. an array of SRRS can exhibit negative effective permeability. The SAR value has been observed by varying the distances between head model to phone model, different widths, different thicknesses, and different heights of materials and meta material design. The SRRs consist of two concentric square rings, each with gaps appearing on the opposite sides. The resonant frequency ω is very sensitive to small changes in the structure parameters of SRR. The simulation of this structure is done by using FDTD (finite-difference time-domain) method for analyzing the SAR reduction effectiveness. For this analysis is done using six layer human head model is called Lossy-Drude Model.

4. Adding a small metal strip – In this method adding a small metal strip [8] on the backside of the antenna of a mobile handset. The studies on this method show that the metallic strip can reduce the overall size of the antenna and the resonating frequency is reduced. It also modifies the directional pattern of the antenna in the elevation plane to a pattern suitable for mobile- handset. The size of antenna also depends on SAR value, therefore miniaturization of antenna also reduce the SAR value. The simulation model used in this method SAM phantom head model.

5. Compensation method – In this method there is adding an auxiliary antenna between the transmitting (main) antenna and the user's head [9]. The compensation method for creation of a weak field area near a transmitting antenna provides for reducing irradiation of mobile phone user's head, without sacrificing the antenna's far field pattern. This method is implemented by using a PIFA antenna and a MB antenna. The MB antenna is the modified monopole antenna. The evaluation of SAR in this method by comparing the local SAR and total SAR values when compensation method is applied and to single antenna case. In this method the SAR value is reduced very efficiently.

6. Designing of different meta material for SAR reduction.

Artificially created materials having electromagnetic properties not generally found in nature such materials are called meta materials [7]. Split Ring Resonator, electromagnetic band gap (EBG) structure are an example for meta material. So that to reduce SAR, designing a different meta material is also a method. For example designing of square meta material for reducing the SAR by placing SMM between the head and the antenna [10-11]. To build the SMMs for SRR structures were used as the resonator model. The finite-difference time-domain (FDTD) method with lossy-Drude model is used in this analysis. The absorption electromagnetic energy is different at the different parts of the body. This table shows the different methods which are implemented to reduce the SAR value and also this give different head model and SAR output variation in different method.

Antenna used	Method used	Head model used	Frequency	Simulation tool used	output
Planar Monopole	Miniaturization of antenna	CST 2012 hugovoxel dispersive model.	900MHz	HFSS	To acceptable level
PIFAor modified monopole	Miniaturization of antenna by using meta material	Phantom head model	2.4 GHz	SEMCAD X	SAR value lowered than modified monpole
PIFA &MB	Compensation method	Phantom head model	PIFA-0.9GHz MB-1.30GHz	CST	Total SAR decreased by 15.5dB local SAR by 16.9dB
PIFA	Meta material design	lossy-Drude model	900MHz	CST MWS with FDTD	1.0623 W/kg for SAR 1 gm
Small patch antenna	Miniaturization of back antenna	-NIL-	1800MHz	Full wave solver	EM field at (front- back) >10dB
Monopole	Adding metal strip	-NIL-	1800 MHz	HFSS	Resonating frequency reduced from 2.4ghz to 1.8GHz

Table 1. Different SAR reduction methods implemented

IV. Conclusion

The studies on the SAR reduction methods for mobile application reveal the idea for designing healthy antenna's for mobile application. The efficient method to reduce the SAR is designing of meta materials. Size, position, thickness of an antenna also matters in case of SAR. SAR value is a important parameter in case of mobile devices. SAR is also a crucial parameter in antenna design.

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