SAR experience related to human exposure

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Abstract: This paper tries to study and analyze the various operating parameters which can influence SAR definition and value. The key parameters that influence SAR include distance, frequency phone angle, Tissue type and Age.

Keywords: mobile phone, specific Absorption rate SAR, tower, electromagnetic fields.

INTRODUCTION

The wide spread use of wireless communication device which close the proximity to the human body remains a topic of growing concern to the public. There is a need to evaluate this electromagnetic interaction of wireless device with a human brain in order to establish the safety of the wireless systems. There have been considerable research activities to investigate the biological effects of electromagnetic fields [1].These activities are influenced by factors like the rate of RF energy deposition in biological tissues, called specific absorption rate (SAR) to access the potential health effects.

A human body is a homogeneous, loss dielectric whose electrical properties can be influenced when a electric or magnetic field penetrate in to the body, the intensity EM field that penetrate in human body depend on number of internal and external parameters like, frequency, polarization, antenna type & distance, size & shape and dielectric properties of the exposed body size & thickness of RF shield.

International organizations like IEEE and ICNIRP have set standard for exposure limits in terms of SAR. In IEEE standard [2] the peak SAR as averaged over any 1 g of tissues should not exceed 1.6w/kg while in ICNIRP guide lines [3] the peak SAR as averaged over any 10 g of tissue should not exceed 2w/kg. In the present study is to examine the various parameters which influence SAR.

SUBJECT AND METHOD

Guidelines and recommended limits on human exposure to radio waves give basic restriction in terms of SAR or power flux density and also reference levels in terms of field strength in absence of the body. *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 given mass density (ρ):

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

And it is expressed in units of watt per kilogram (W/kg). *SAR* can be calculated also by:

$$SAR = \frac{\sigma E_i^2}{\rho}$$

Or

$$SAR = c_i \frac{dT}{dt_{(time=0)}}$$

Where E_i is rms value of the electric field strength in the tissue in V/m, σ is conductivity of body tissue in S/m, ρ is density of body tissue in

kg/m^3, c_i is heat capacity of body tissue in J/kg K, $\frac{dT}{dt}$ is time derivative of temperature in body tissue in K/s[6].

THE LOCAL SAR MEASUREMENT

The specific absorption rate depends on distance. It can be seen from the graph ploted below that SAR varies inversely with the distance from the transmission tower. In the case of 1800 MH_z frequency band, SAR very high nears the tower. It exceeds the international standard limits up to 15 to 20 meters away from the tower.

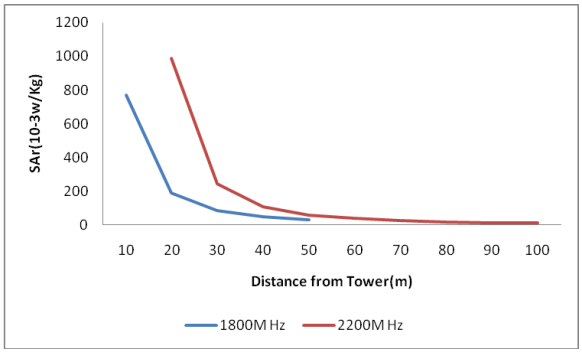

Figure 1: Variation of SAR Vs distance from the tower (Meters).

From the Graph it can be seen that SAR values comes to low level after a distance of 35 – 40 meters of away from tower. From the graph it can be concluded that irrespective of the operating frequency, graph ploted are of same nature. From the graph it can be concluded that irrespective of the operating frequency, graph plotted are of same nature.

A human being living near the tower is continuously exposed to radiation emitted by the mobile tower. The amount of energy/radiation absorbed is not constant through out the body, it will be different, depending on the type of part exposed. The amount of energy absorbed by the skin is different from what absorbed by bone, it will depend on dielectric properties of body part exposed.

The table below shows electric conductivity and dielectric properties of the body parts, main skin, brain, and bone is given. The parameter varies with respect to operating frequency.

Body Part	900 MHz		1800 MHz		2200 MHz	
	?r	?	?r	?	?r	?
Skin	39.5	0.7	38.2	0.9	37.1	1.1
Bone	12.5	0.17	12.0	0.29	11.7	.35
Brain	56.8	1.1	51.8	1.5	47.5	1.8

Table1: The properties of the Parts of Body under different frequency of operation

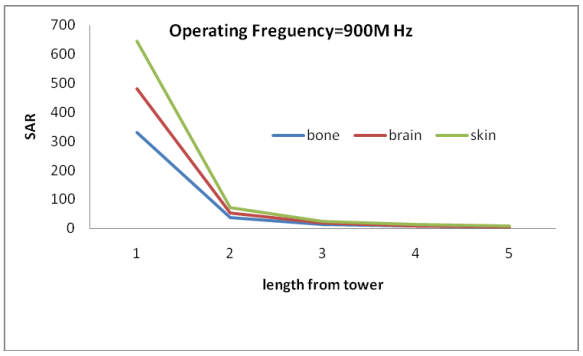

Figure 2: Variation of SAR Vs length of the tower (Meters) at 900MHz.

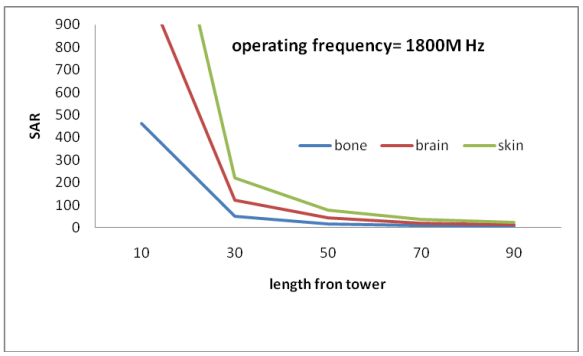

Figure 3: Variation of SAR Vs length of the tower (Meters) at 1800MHz.

Figure (2) and (3) represent s the several of energy absorbed by skin, brain and brain at various distance from the tower as a function of operating frequency.

Figure (2) says that skin absorbed maximum to energy then born & brain at distance close to tower.

Figure (2) & (3) says that S.A.R absorbed by the body increase with increase in operating frequency.

One way of reducing SAR in the human head is by attaching RF Shield made of ferromagnetic material to the front side of the mobile phone [5]. The mechanism behind reduction of SAR is due to the suppression of surface currents of the front side of mobile phone box. When an EMW travelling trough free space encounters a different medium, the wave will be reflected, transmitted and / or absorbed. EMW absorption materials absorbed the energy in electromagnetic waves as magnetic loss and convert that energy in the end to heat.

Generally dimension of RF shield is specified as $X \times Y \times Z$, where X is the thickness of the shield; Y is the width of the shield and Z length of the shield. Experiments were done to study the variation in SAR once, the dimension are changed [5].

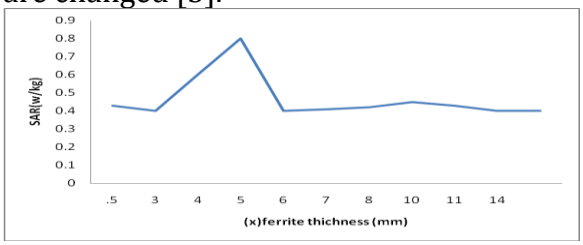

Figure 4: SAR vs Ferrite thickness

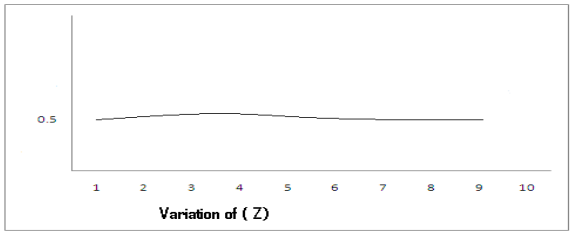

Figure 5: SAR vs Variation of z

The cellular based stations are transmitting signal (radiation) continuously even nobody is using the phone.

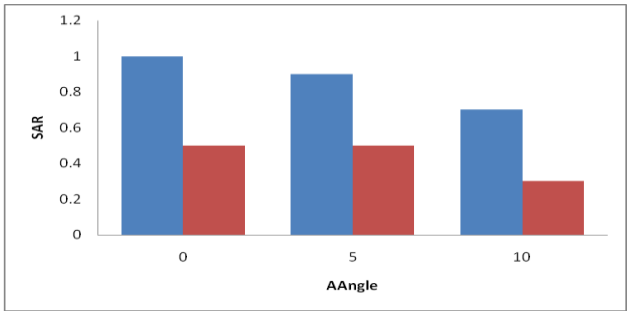

Figure 6: SAR as a function of hand set inclination.

From one study reported [4] the energy absorbed by the head, from the mobile phone

varies slightly, with variation in phone inclination.

Another study says that if we keep phone at slight distance away from the head, the S.A.R will reduce slightly. This variation is plotted below.

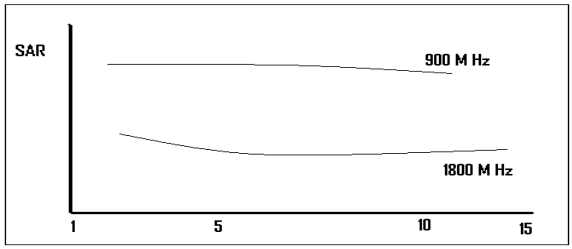

Figure 7: Distance from the Head to Mobile Phone

CONCLUSION

From the above discussion the author came to the conclusion that S.A.R cannot be specified to a single value, has mentioned by international organization at present. Author says that SAR will depend on a number of factors, like distance from tower , properties of body parts, phone inclination, distance between Mobile phone and head, phone inclination RF Shield etc. So any variation in any of these parameters will directly affect SAR. So author concludes that S.A.R should always mention with some boundary conditions.

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