International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-1 Issue-6, November 2012

Effect of Permittivity and Conductivity of Tissue on Specific Absorption Rate of Electromagnetic Radiations

Amarjeet Kaur, Himani Malik, Vandana Tanwar, V.K.Lamba, Nitesh Kumar, Sanjay Sharma

***Abstract:** In this paper a novel approach for analyzing effect of conductivity and permittivity of human tissue on penetration of electromagnetic radiations inside tissue. Moreover, we concentrated our work on analyzing the other related factors describing system performance like Voltage Standing Wave Ratio (VSWR)& return loss. We simulated tissue by setting different electrical and magnetic properties and used 900MHz communication frequency to simulate antenna for analyzing its effect in terms of variation in Specific Absorption Rate (SAR) of electromagnetic radiations (produced by handheld communication devices) in Human tissues at different permittivity and conductivity.*

***Index Terms:** Specific Absorption Rate; EM Radiations; Electromagnetic waves; SAR; XFDTD; Communication Frequency; Return loss; Voltage Standing Wave Ratio (VSWR); Human tissue; Electrical & Magnetic properties of human tissue, conductivity, permittivity.*

I. INTRODUCTION

Mobile phones have become an integral part of human's daily life. The feature of connectivity during mobility is one of the most attracting feature of mobile phones. When mobile phones are two way radios which transmit and receive signal by emitting and receiving electromagnetic radiations. When these mobile phones are used in close proximity with human body, then these radiations get penetrated in to human body tissues, which are in close proximity with mobile phones.

Specific Absorption Rate (SAR) is parameter used for measuring the penetration of electromagnetic radiations in human body. The unit of SAR is watt per kilogram (W/Kg). SAR is defined as where σ and ρ are the conductivity and density of the human body tissues respectively and E is the electric field in the tissues.

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

Revised Manuscript Received on 30 November 2012
*Correspondence Author(s)
Er. Amarjeet Kaur*, Department of Electronics and Communication Engineering, ACME, India.
Er. Himani Malik, Department of Electronics and Communication Engineering, HCTM, India.
Er. Vandana Tanwar, Department of Electronics and Communication Engineering, HCTM, India.
Dr. V. K. Lamba, Department of Electronics and Communication Engineering, HCTM, India.
Er. Nitesh Kumar, Department of Electronics and Communication Engineering, HCTM, India.
Asst. Prof. Sanjay Sharma, Department of Electronics and Communication Engineering, ACME, India.

Moreover human body also put some effects on performance of mobile phone antennas. Just for analyzing these effects, we have simulated tissue on varying density, permittivity & conductivity of tissue.

II. GEOMETRY USED FOR SIMULATION

Using software XFDTD 7.2.3, we have created geometry of tissue with a dipole antenna in close proximity. Geometry comprises of three parts i.e. Flat phantom, Phantom shell and a Dipole. Flat Phantom represents tissue simulating liquid which is being used for SAR measurement. Flat Phantom is a rectangular extrusion of dimension 220 X 150 mm with an extrusion in the +Z direction of 150mm. Flat Phantom is assigned the properties of tissue simulating liquid i.e. electrical properties as isotropic, magnetic properties as free space. The conductivity, relative permittivity and density are initially set as 0.9 S/m, 41.5 & 1000Kg/m3 respectively.

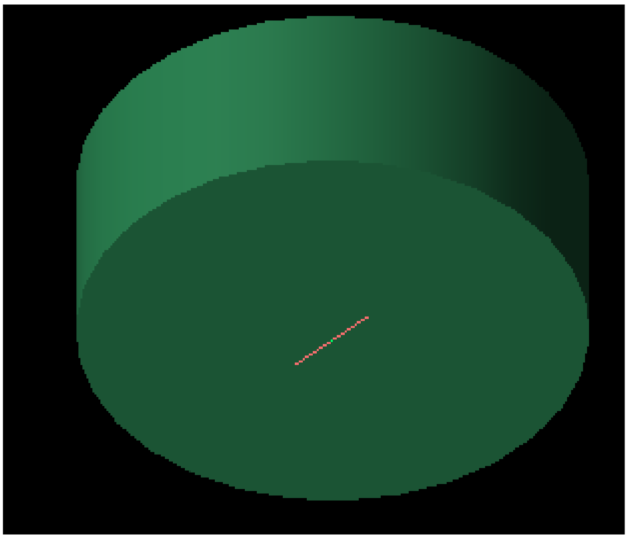

Figure1: Finished Geometry of Tissue

Whereas the Phantom Shell is a plastic vessel that will hold the simulating liquid (Flat Phantom). For our simulation, we require only add the bottom of Phantom shell that separates the liquid from dipole source. We have kept this shell size same as that of Flat Phantom in X, Y dimensions and have a thickness of 2mm. We have assigned the electrical properties to Phantom shell as isotropic & magnetic properties as free space. The conductivity & relative permittivity are set as 0S/m& 3.7 respectively. After creating the geometry of tissue, we have designed a simple dipole antenna which comprises of two cylinder extrusions of radius 1.8mm and a length 161mm with a gap, where a voltage source of 50 ohm voltage source.

*Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)*

We have assigned electric and magnetic properties as perfect electric conductor & free space respectively. We have added SAR sensors for collecting the values of 1g and 10g average SAR data. This tissue is being simulated at 900MHz frequency.

III. RESULTS

A. *Effects of Conductivity Variations:*

We have measured average SAR values by varying conductivity of tissue and keeping rest all parameters unchanged. Table 1 shows the results we have measured for this tissue model at different conductivities.

Table 1 Simulation results for different conductivities

Conductivity (S/m)	Average SAR (W/Kg)	VSWR	Reflection coefficient	Return Loss
1	0.1596	2.279	0.39	8.18
2	0.1484	2.592	0.4433	7.07
3	0.1397	2.858	0.4815	6.35
4	0.1378	3.02	0.5025	5.98
5	0.1272	3.261	0.5306	5.5
6	0.1225	3.422	0.5477	5.23
7	0.1185	3.564	0.5618	5.01
8	0.1149	3.686	0.5732	4.83

As shown in Figure 2, SAR values show a decrease in SAR value with increase in conductivity of tissue. The highest value of 0.1596 Kg/W SAR is achieved at 1S/m. then it goes on decreasing with further increase in conductivity of tissue & the lowest value 0.1149 W/Kg is achieved at 8 S/m.

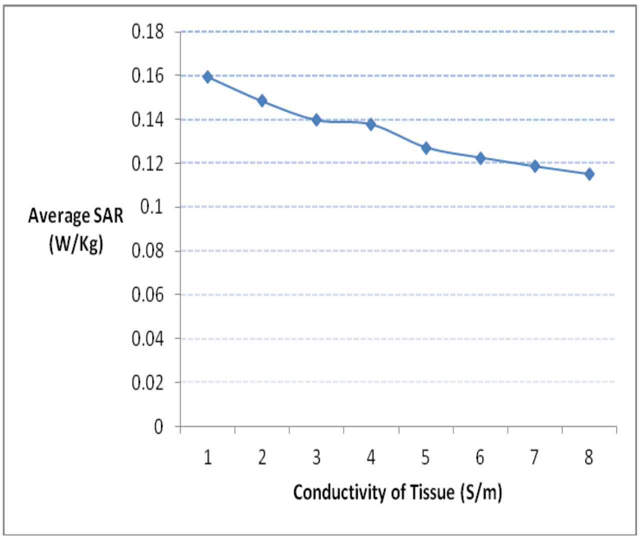

Figure 2 Variation in SAR with varying Conductivity of tissue Figure 3 shows that return loss shows a gradual fall with increase in conductivity of tissue. For higher value of conductivity lesser will be the return loss. As shown in graph the highest return loss of value 8.18 dB is noticed at 1S/m. while a lowest value of 4.83 dB is achieved at 8 S/m.

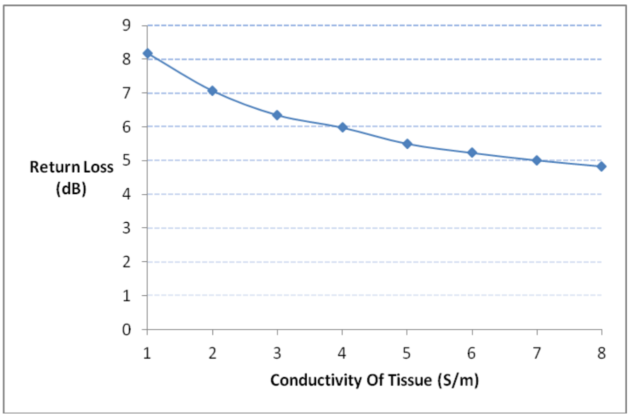

Figure 3 Variation in Return Loss with varying Conductivity of tissue

Figure 4 shows that VSWR shows a gradual increase with increase in conductivity of tissue. For higher value of conductivity higher will be the VSWR. As shown in graph the highest VSWR 3.686 value is gained at 8S/m. while a lowest value of 2.279 VSWR is achieved at 1 S/m.

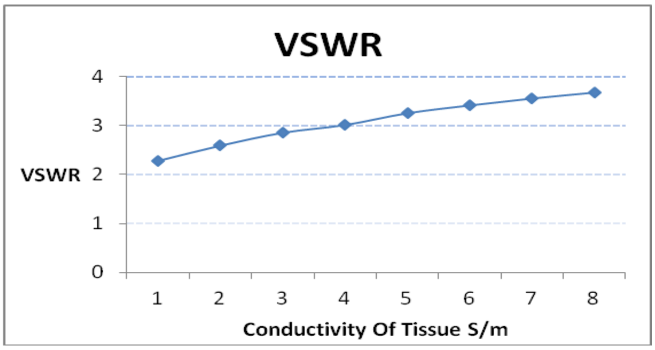

Figure 4. Variation in VSWR with varying Conductivity of tissue

B. *Effects of Permittivity Variations*

We have measured variation in SAR values by varying permittivity of tissue and keeping rest all parameters unchanged. Table 3 shows the results we have measured for this tissue model at different permittivity.

Table 2. Simulation results for different conductivities

Permittivity	Average SAR (W/Kg)	VSWR	Reflection coefficient	Return Loss
10	0.1343	3.087	0.5106	5.84
20	0.1406	2.862	0.4821	6.34
30	0.1451	2.707	0.4605	6.74
40	0.148	2.604	0.445	7.03
50	0.1536	2.494	0.4276	7.38
60	0.1536	2.494	0.4276	7.38

As shown in Figure 5, SAR values show an increase in SAR value with increase in permittivity of tissue. As higher value of permittivity is set, higher SAR value is achieved. Keeping health & safety point of view, as lower is the permittivity of tissue then lower will be the SAR values.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

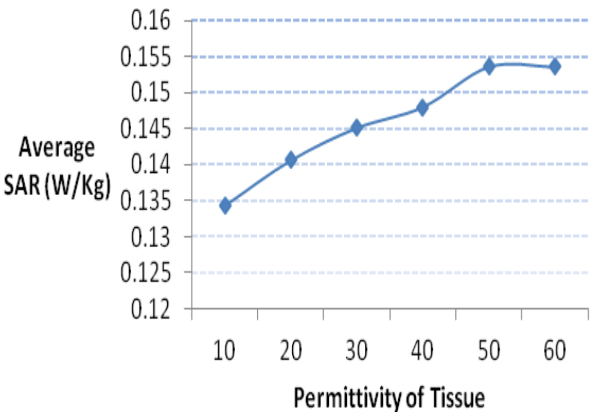

Figure 5. Variation in SAR with varying Permittivity of tissue

Figure 6 shows that VSWR gradually falls with increase in permittivity of tissue. For higher value of permittivity lower will be the return loss. As shown in graph the highest VSWR of value 3.087 is noticed at permittivity 10. While the lowest value of 2.494 is achieved at permittivity of 10.

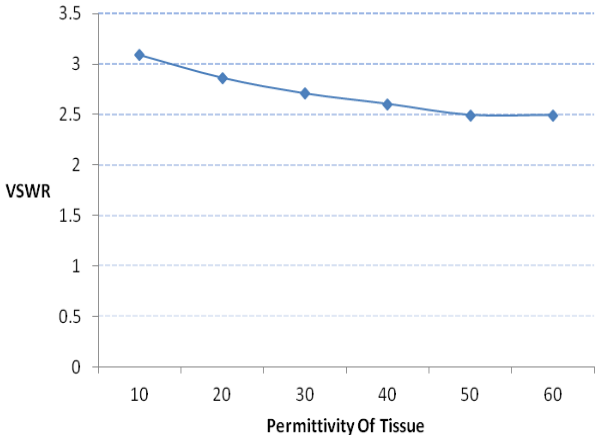

Figure 6. Variation in Return Loss with varying Permittivity of tissue.

Figure 7 shows that return loss gradually increases with increase in permittivity of tissue. For higher value of permittivity higher will be the return loss. As shown in graph the highest Return loss 7.38 value is gained at permittivity of 60. while a lowest value of 5.84 Return loss is achieved at 1 S/m.

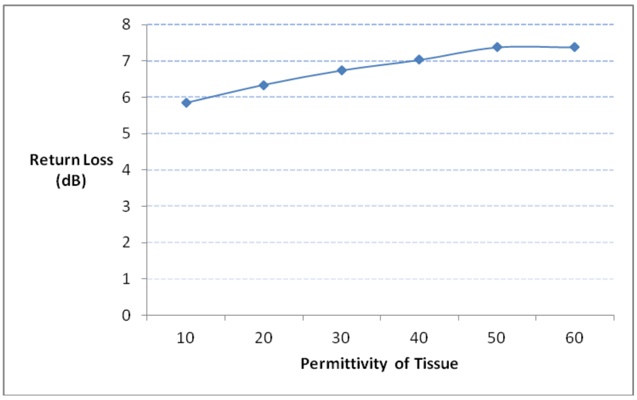

Figure7. Variation in VSWR with varying Permittivity of tissue

IV. CONCLUSION

We have tried to conclude the effect of density variations on SAR value. From above simulation, we made following conclusions.

Firstly, we concluded that SAR value decreases with increase in conductivity. So, There will be more absorption of EM radiations in tissue with lower conductivity than those with higher conductivity. It can also be concluded that Return loss also decreases with increase in conductivity. While VSWR increases with increase in conductivity of tissue. As higher is the conductivity of tissue lower will be the VSWR value.

Second conclusion can be drawn from here is that SAR value increases with increase in permittivity. So, There will be more absorption of EM radiations in tissue with higher permittivity than those with lower permittivity. It can also be concluded that Return loss also increases with increase in permittivity. While VSWR decreases with increase in permittivity of tissue. As higher is the permittivity of tissue, lower will be the VSWR value.

REFERENCES

1. Salah I. Al-Mously, "Assessment Procedure of the EM Interaction between Mobile Phone Antennae and Human Body" Pedro Pinho12, Amelia Lopes1, Joao Leite1 and Joao Casaleiro, "SAR determination and influence of the human head in the radiation of a mobile antenna for two different frequencies", IEEE Trans., 2009
2. Ali Zamanian and Cy Hardiman, "Electromagnetic Radiation and Human Health: A Review of Sources and Effects" in High Frequency Electronics,16-26, July 2005
3. Shalatonin V. I., "Mobile Phones and Health: The Key Role Of Human Body Flids in Bioeffects of Non-Thermal EM Radiation" in 200818th Int. Crimean Conference "Microwave Telecommunication Technology" (CriMiCo'2008). 8-12 September, Sevastopol, Crimea, Ukraine© 2008: CriMiCo'2008 Organizing Committee; CrSTC. ISBN: 978.966.335.166.7. IEEE Catalog Number: CFP08788
4. B. Blake Levitt and Henry Lai, "Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays" in Environ. Rev. 18: 369–395, 2010
5. P. Salonen, L. Sydanheimo, M. Keskilammi, M. Kivikoski,"A small planar inverted-F antenna for wearable applications," Wearable Computers, 1999. Digest of Papers. the Third International Symposium on, pp. 95-100, 1999.
6. C. Hertleer, A. Tronquo, H. Rogier,L. Vallozzi,L. Van Langenhove, "Aperture-Coupled Patch Antenna for Integration Into Wearable Textile Systems," Antennas and Wireless Propagation Letters, IEEE, vol. 6, pp. 392-395, 2007.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)