Portability of Skin Tissue for Prevention of High Specific Absorption Rate (SAR) in Inner Tissues at ISM and MICS Frequencies

A. G. Saber
Department of EE
Mosul University
College of Engineering

Y. E. Mohammed Ali
Department of EE
Mosul University
College of Engineering

ABSTRACT
The main purpose of this paper is studying the portability of the human's skin tissue to protect the internal tissues from radiation. This study shows that the increase in the thickness of the skin tissue reduces the value of the specific absorption rate (SAR) within the internal tissues. This explains the risk of exposure of children and newborns to radiation from different devices, especially high-power devices. Phantom Models of the human body were simulated from a group of tissues using CST software. The plane wave used by exposing phantom model to radiation and using four frequencies that were most commonly used. A number of Phantom models with different thickness were simulated. This study showed that the effectiveness of the skin tissue to protect of radiation risk, especially the thick skin tissue. The results also showed an increase in the values of the specific absorption rate within the skin tissue and decrease in the values of the specific absorption rate within the internal tissues.

Keywords
Electric field; Water content; Human tissue; CST; SAR; Skin; Muscle.

1. INTRODUCTION
In recent decades, the study has forwarded to study the behaviour of the electric field inside the human body, which is one of the important subjects for the purpose of estimating the values of Specific Absorption Rate (SAR), which in turn is considered the basis in estimating the amount of heat generated by the exposure of any part of the human body to the electromagnetic fields. there are many applications which give interesting for study the behaviour of electromagnetic fields inside tissues, such as study the effects of electromagnetic waves produced by devices which used by people, as well as in therapeutic and detection applications. Hyperthermia unit regarded one of therapeutic applications, CT scan regarded one of applications. The most common and used frequencies are (402MHz, 915MHz, 2.45GHz, 5.8GHz) [1],[2], for ISM (Industrial Scientific and Medical) for frequencies 915MHz, 2.45GHz and 5.8GHz, and MICS Medical Implant Communication System for frequency 402MHz, these bands of frequencies are most commonly used in different fields. The SAR can be evaluated using the following equation[4][5].

$$SAR = \frac{\sigma E^2}{\rho} \left({}^{W}/_{Kg} \right) \qquad (1)$$

Where σ represented conductivity, E electric field and ρ the density

2. PHANTOM MODEL OF HUMAN TISSUES
The phantom model which has used for simulation plane wave, free space and human tissues consisted of three layers: air, skin, fat and muscle with size 40mm × 40mm and thickness 30mm for muscle tissue, 10mm for fat tissue and skin tissue various thickness 1.5mm, 2mm and 4mm, additionally to 10mm free space between the phantom model and the source which represented by plane wave 1V/m. The physical structure showing in Figure 1, which consisted of various tissues.

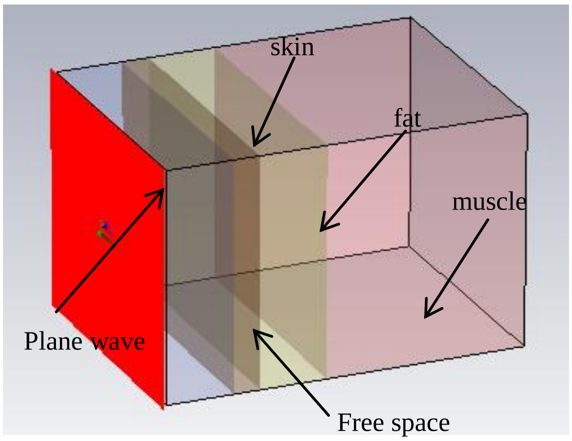

Fig 1: The phantom consisted of plane wave, free space and human tissues (skin, fat and muscle).

3. ELECTRICAL PROPERTIES OF HUMAN TISSUES
The electrical properties are important for evaluating E-field and SAR. The tissues of human body are mostly consisted of water and few other elements such as carbon, hydrogen, oxygen and nitrogen[3]. The recent researches show that the electrical properties of human tissue are changing with frequency[6][7][8]. The electromagnetic properties of human tissues consisted of permittivity and conductivity. The values of these parameters had measured and available in database[7]. Table 1, contains some information about the electric properties for different tissues at different frequencies [8].

Table 1. Electric Properties of Human Tissue at different frequencies [7]

Frequency		Skin	Fat	Muscle
402MHz	ε_r	49.4	5.45	54.9
	σ(S/m)	0.68	0.05	0.94
	Rho (kg/m^3)	1010	920	1024
915MHz	ε_r	41.3	5.45	54.9
	σ(S/m)	0.87	0.05	0.94
	Rho (kg/m^3)	1010	920	1024
2.45GHz	ε_r	38.0	5.28	52.7
	σ(S/m)	22.5	117	22.3
	Rho (kg/m^3)	1010	920	1024
5.8GHz	ε_r	35.1	4.95	48.4
	σ(S/m)	3.71	0.29	4.96
	Rho (kg/m^3)	1010	920	1024

4. E-FIELD AND SAR IN MISCLE TISSUE ONLY

In order to estimate the specific absorption rate within tissues, starting by estimating the value of the electric field, and then estimate the specific absorption rate for the different cases, this means the different layers and at different frequencies and using the planet wave, by representing the tissue using the CST simulation program taking into account tissue density for estimating the Specific Absorption Rate. The phantom which used in this case consisted of 10mm free space and 30mm muscle tissue, beginning, the electric field and the specific absorption rate are determined by propagation of electromagnetic waves from the air directly to the muscle tissue alone, the purpose is to compare the results with the following cases, when other tissues are added to the muscle tissue. By applying plane wave of a value 1V/ m at different frequencies, the electric field and specific absorption rate will be plotted as a propagation function with the depth of the muscle tissue see Figure 2 and Figure 3.

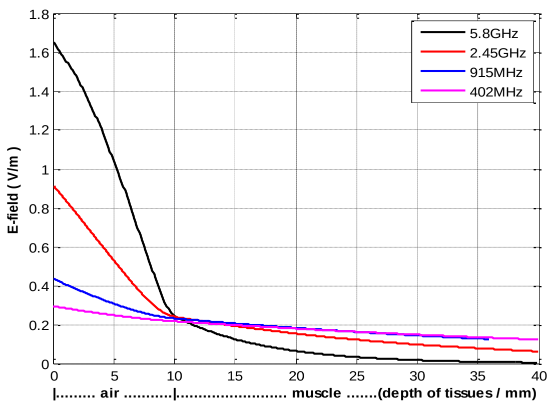

Fig 2: Propagation of electric field through a medium of air and muscle using a plane wave at different frequencies.

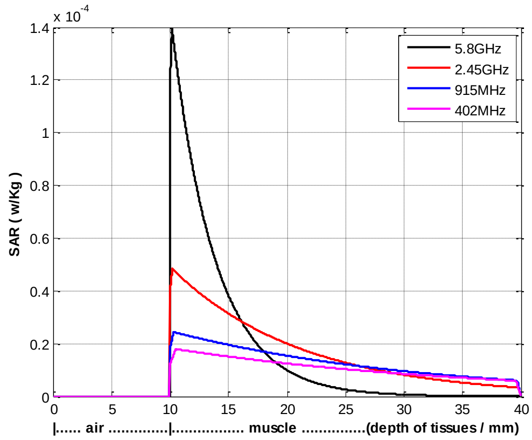

Fig 3: Specific absorption rate in muscle tissue at different frequencies.

It can be observed that the highest values of the specific absorption rate are at high frequencies. The difference in SAR values between the highest frequency of 5.8GHz and the lowest frequency of 402MHz is about 9.8dB. This means that high power will be deposited inside the muscle tissue at high frequencies, it is also possible to observe that the attenuation of the electric field and specific absorption rate decreases at high frequencies as in Figure. 2 and Figure 3.

5. E-FIELD AND SAR IN PHANTOM MODEL

In this paragraph will add a 10mm fat tissue to the muscle tissue, the value of the electric field and absorption rate was also plotted as a function of tissues thickness which consisted of fat and muscle tissues, as showing in Figure 4 and Figure 5, by comparing SAR values In Figure 3 where the fat tissue was not present and between Figure 5 which contains the fat tissue, noted a slight increase in SAR value in the muscle tissue if fat tissue is present at frequencies 402MHz, 915MHz and 2.45GHz, While was observed low absorption rate at 5.8 GHz, in addition, noted in Figure 4 that the values of absorption rate in the fat tissue are small compared to the SAR values in the muscle tissue, The reason is the low value of conductivity of fat compared to conductivity of muscle tissue. While the decrease and increase of the electric field values and the specific absorption rate within the fat tissue at some frequencies is the relationship between frequency and wavelength within the tissue λ_g. At frequencies of 2.45GHz and 5.8 GHz, the thickness of fat tissue is close to order $\lambda_g / 4$, which explains the rise in absorption rate values due to constructive interference at some points of the fat tissue.

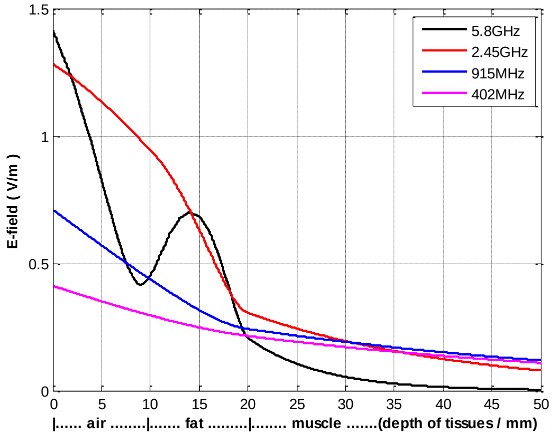

Fig 4: Propagation of electric field through a medium of air, fat and muscle tissues using a plane wave of different frequencies.

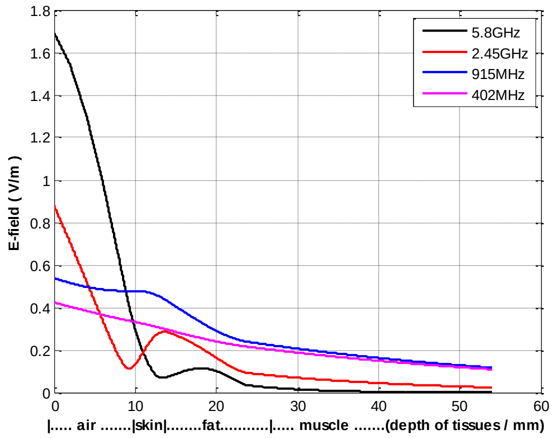

Fig 6: Propagation of electric field through a medium of air, skin, fat and muscle tissues using a plane wave of different frequencies.

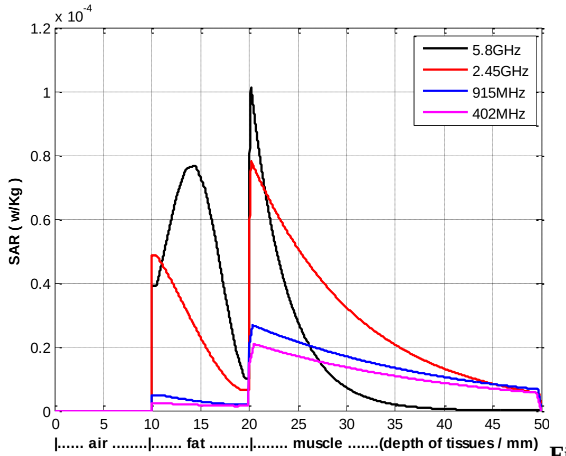

Fig 5: Specific absorption rate in fat and muscle tissues at different frequencies.

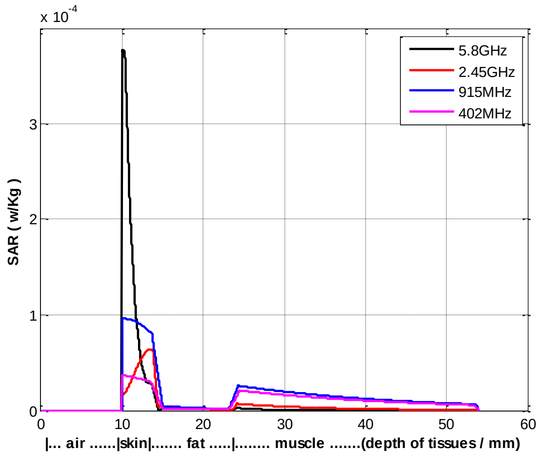

Fig 7: Specific absorption rate in skin, fat and muscle tissues at different frequencies.

6. E-FIELD AND SAR IN PHANTOM CONSISTED OF SKIN, FAT AND MUSCLE TISSUES

propagation of plane wave from air into a three-layer medium a moist skin tissue, fat tissue and muscle tissue, the skin tissue ranges between 1.5mm and 4mm and therefore will test the cases at important frequencies. In Figure 6 the value of the electric field and Figure 7 the absorption rate were plotted as a propagation function with the depth of the model. By Comparing the SAR results between Figure5 in the case of the two-layer and the Figure 7 consisting of three layers, the 4mm thickness of the skin layer, noted the importance of this layer to reduce SAR in the depth of the muscle tissue.

7. ESTIMATION OF SAR USING VARIOUS SKIN

A 2.45GHz plane wave used in this case, a phantom consisting of muscle tissue, fat tissue and a variable skin tissue was represented in four models. In the first model, muscle tissue and fat tissue were only formed. The second model consisted of muscle tissue and fat tissue associated with 1.5 mm skin tissue thickness, the third model consisted of muscle tissue and fat tissue associated with 2 mm skin tissue thickness, finaly the ford model have skin tissue of 4mm., Figure 8 showing the SAR in overall phantoms which used in this case

It can be observed that the difference in the SAR value between the thickness of the skin tissue is 4 mm and the absence of the skin tissue, difference up to 10.45 dB and the thickness of the skin tissue of 2 mm and the absence of skin tissue difference up to 6.6 dB and the presence of tissue thickness The skin of 1.5mm and lack of skin tissue difference up to 4. 8dB as showing in Figure 9.

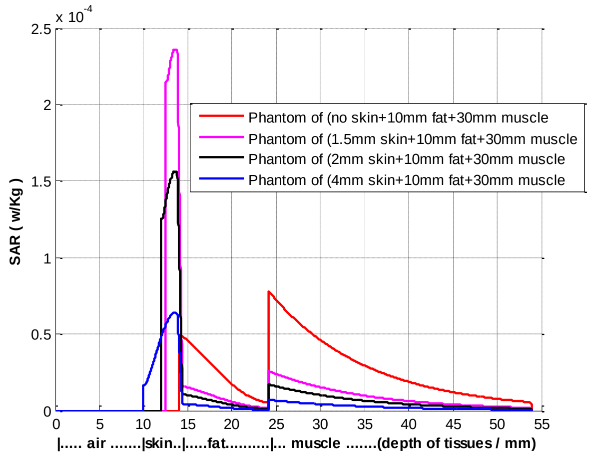

Fig 8: Specific absorption rate within the phantom model at 2.45GHz frequency for different cases in terms of changing the thickness of the skin tissue.

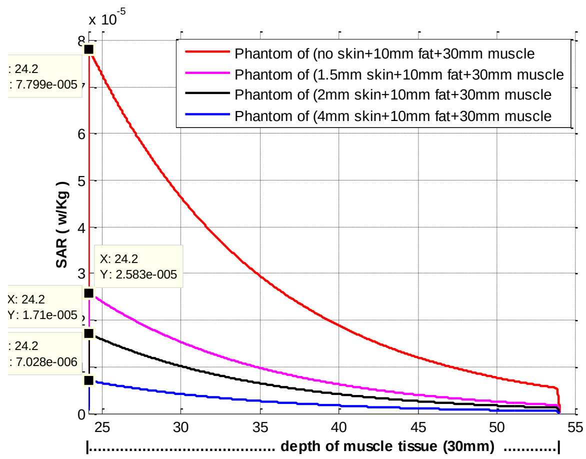

Fig 9: Specific absorption rate within muscle tissue at 2.45GHz frequency for different cases in terms of changing the thickness of the skin tissue.

8. DISCUSSION AND CONCLUSIONS

The results was showing increasing in the values of the specific absorption rate at high frequencies within the muscle tissue where the difference in SAR between the highest frequency and the lowest frequency is about 9.8dB, and when adding the skin tissue, which is a layer to protect the internal tissues, which reduce the rate of absorption rate in the internal tissues of muscle tissue and the rest of all tissues, where the skin absorbs a large proportion of energy and thus decreases the energy entering the body and can be observed by controlling the thickness of the skin tissue. When increasing the thickness of the skin tissue added to the muscle tissue and fat tissue , the difference in SAR value within the muscle tissue between the presence of the skin tissue with 4mm thickness and its absence reached to 10.45dB and between the presence of the skin tissue thickness of 2mm and its absence reaches, the difference to, 6.6dB and the presence of skin tissue thickness 1.5mm and its lack up the difference to 4. 8dB.

9. REFERENCES

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