Study the Effect of Mobile Handset Radio Frequency on Human being Health

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Abstract

This work includes study and evaluation of Specific Absorption Rate (SAR) of electromagnetic waves in human body (head and hand). The radio frequency (RF) waves which are normally radiated from the handset mobile phones, are widely used nowadays by the people of different ranks and ages. This topic which has attracted the attention of the researchers in the later time. The evaluation process needs three elements to be presented. The human head, hand and the handset mobile. Both homogenous model of SAM (Specific Anthropomorphic Mannequin) head and hand and heterogeneous model of head (voxel) are used in this work. The human hand is designed with seven layers to be near the heterogeneous (real) hand. The handset mobile is designed by the designer with patch antenna of four bands: 900MHz, 1800MHz, 2100MHz and 2400MHz. The process of evaluation is done for different positions situations and handling of handset mobile phone with respect to the vertical head axis for both homogenous and heterogeneous models. The results show that the values of SAR are more real for heterogeneous model than homogenous one. In addition, the results observed that maximum SAR point was in the index finger for all the considered frequencies and SAR was reduced by 70% for moving the mobile with 10mm away from the head, and by 80% for moving the mobile by 20mm away from the head. The SAR evaluation has been done using the simulation model in the CST package.

Keywords: SAR, SAM, Voxel, Handset Mobile.

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1. Introduction

The developments in the wireless communication systems lead to widespread use of the handset mobiles. The cellular mobiles are not used only by limited rank of peoples, but it because to be available for the peoples, independent of the rank, age or job…etc. These services are of great of importance, because of facilitating the jobs or saving long times which may be spend to do certain jobs or services. In spite of the previous advantages of the cellular phones. They have many disadvantages, among which the health hazards which may happen, using the mobile for a long time may lead to very dangerous diseases, like Cancer Tamurs in the human head on body, or complications for health [1].

The latest years has shown a public interest in this field, which made the researchers to pay a deep attention to this problem.

The problem is simply the human exposure to RF which are radiating from the handset mobiles. The main line of the researches is the knowledge about the specific absorption ratio(SAR), which is the indication of the amount of power absorbed by in the user body, specially, head and hand. For such a purpose the research works may be divided in to three groups: The 1st group which is dealing with the mobile antenna, design, and reduction of the SAR. The 2nd group deals with the SAR in the different human head models, trying to use the models which are near to real human head. The last group deals with the effect of the hand on the power radiated from the antenna and its effect on the value of SAR in the hand &head. Each group has passed through may development stages as will be lighted out in the following lines in brief.

The first group interests are to have an antenna with higher efficiency smaller size and weight, to produce less SAR in the user body (head). For performing such a goal, there were many works done in this field, Pekka [2], designed a PIFA antenna for 3rd G handsets, Riu, and Foster [3], also designed and tested a Patch antenna for a handset mobile, considering different antenna positions on the printed circuit board (PCB). Khalatbari et al. [4], made an improvement in handset mobile antenna and reduced peak SAR up to 60%. Gada, et al. [5], had designed a multi-band antenna used for SAR evaluation test.

The second group interests were in SAR evaluation in human head. Bernardi et al. [6], calculated SAR in a uniform semi-in finite homogeneous plane tissues, considered as head model. He used the commercial FDTD program (XFDTD). Results show that the distance between RF source and the head model was inversely proportional. Abd [7], had evaluated SAR in human head, exposure to RF electromagnetic waves radiated from different commercially available mobile handset antennas. Results show that all the SAR measured values were lower than the accepted standard values. Hsing-Yi et al. [8], studied the effect of exposure time on temperature increase in human head due to different models of the antenna. The results show that the steady state value of temperature reduced after exposure time of about 20 minutes.

Gasmelseed, and Yunus [9], evaluated SAR in two dimensional human head model at 900MHz, due to normal incident plane wave toward coronal and sagittal planes. The results show that SAR was higher for sagittal than corona plane waves. Ayman [10], evaluated SAR inside a simple plane multi-layered human head model. The result show that peak SAR was occurred in the head skin tissue, the SAR and the distance of the mobile to the head were inversely proportional, increasing the distance to 1-2 cm, SAR had reduced by 3 times, for 900MHz &2400MHz, and reduced by 3.5 times for 1800MHz . Omar A. A. et al. [11], investigated SAR distribution in a multi-layered human head model at 900 &1800MHz, due to obliquely incident plane waves. The local SAR was calculated using the new derived formula. Khalatbari et al. [4], studied the interaction between human head model composed of one and six layers [skin, fat, bone, dura (the outer membranes of brain and spinal cord), CSF (colony stimulating factor), and brain and the electromagnetic field source at 900MHz frequency. The results show that the six-layered head models were more reliable than the one layer model. Riu, and Foster [3], evaluated SAR for a human head model of three layers (skin, bone, muscle) at 900 &1800MHz, UMTS /IMT 2000. Mohammad et al [12], evaluated SAR in the human head for different mobile antennas (monopole, helical, patch, and PIFA), measurements performed for variable distance between the head and the source of RF, (0-20 mm), at frequencies 1800, 2200MHz. Results show that monopole gave highest SAR.

The last group of researches interest was the effect of the user hand on the SAR values. Vikass et al. [13], investigated the effect of the hand on the SAR values. The results show that its present during talking has a large influence on the SAR values in the head, specially at 1950MHz. Ojerinde et al. [14], made a comparison between SIIA(Software & Information Industry Association) hand phantom and different human hands for over the air(OTA) power measurement. The results show that all the participants received power less than the hand phantom. Al-Mously, and Abousetta [15], studied the hand-hold impact of EM interaction of handset mobile and human. The results show that the maximum average SAR was observed in the user hand. Al-Mously, and Abousetta [16], studied the influence of human head and hand on SAR. SAR in users head was simulated and measured; results show that the human head and hand considerably affect resulting in SAR variation. Chung-Huan et al. [17], investigated the influence of the users hand holding a mobile to the ear on the peak spatial SAR average over any 1g & 10g of tissue in the head. Numerical simulations were conducted on four mobile phone models, and parameters such as palm-phone distance, and hand position. Both simulation and measurements have found increase in the psSAR in the head of at least 2.5dB due to presence of the hand. Furthermore the psSAR is sensitive to the hand grip, i.e. the variation can exceed 3dB. Riu and Foster [3], investigated the multi-possible hand hold positions of the EM interaction of handset mobile and a human. Their results show that SAR was peak for internal antenna compared to external. Ronald et al. [18], designed an asian-sized hand model for SAR determination at GSM 900/1800MHz.The designed model has been used for SAR determination at various hand positions, when holding a mobile phone during talk mode. The results shows that smaller hand dose have significant affect on SAR in head. Type of tissue has also a significant affect on SAR values, depend on their densities. The hand grip plays a major role in determining SAR in the head. Samsuri et al. [19], studied the effect of jewelry and humans hand on SAR. The results show that the human hand has significant affect on SAR. The metallic rings worn on the hand tend to reduce the SAR. The wrist worn bangle has very small effect on SAR for all frequencies tests. The earring could significantly influence the SAR depend on its diameter, and position relative to head. The figure ring show minor changes in the SAR values.

From previous overview one can see that there is a need for more study of SAR at wide ranges of frequencies using more realistic hand model. This is what present work is dealing with. Designing a more realistic hand model and using a multi- band antenna designed by Gada, et al. [5], for SAR evaluations.

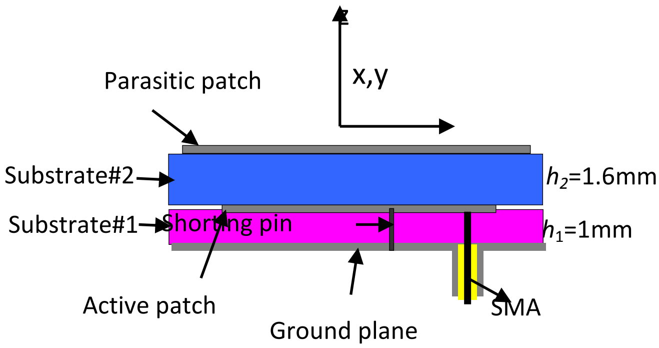
2. Test System Construction

The SAR evaluating system in this work includes mobile phone, human head and hand different models. The system elements are explained in detail in the following pages:

The designs and simulations is conducted in CST Studio Suite 2011 [20] witch embeds Microwave Studio for fast and accurate 3D EM simulation of high frequency problems. Transient Solver is used to solve electric field value, power loss density and S-parameters. Using a fast Perfect Boundary Approximation (FPBA) mesh technology is used to define meshes at high dielectric properties area. SAR calculation will be performed at 1g and 10g averaging mass after transient solver stops.

2.1. Mobile phone

A handset mobile phone with patch antenna designed in[5] is used in this work. It contains quad band multi-layer patch antenna with dimensions 5 x 6 cm shown in Fig.1.a, is fixed on printed circuit board (PCB) with battery. The set covered with plastic box and LCD monitor (taken from a Galaxy-2 mobile phone) as in Fig.1.b.



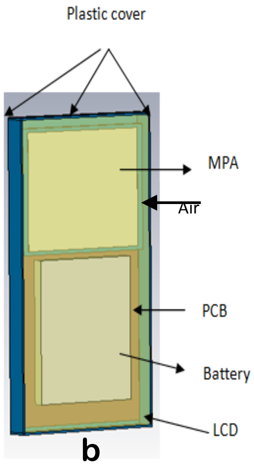
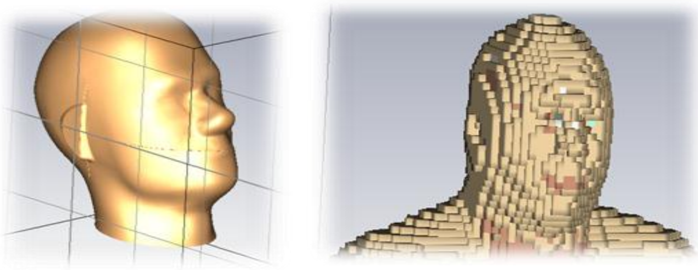


Fig.1: a. quad-band MPA. b. Handset mobile phone.

2.2. Head model

Two head models are shown in Fig.2 used, homogenous and heterogeneous. The homogenous model is taken from the CST package. Heterogeneous is taken from the [20]. The evaluations process is applied on the two following models.



a b

Fig.2: a. Homogenous. b. Heterogeneous

2.3. Hand model

For the purpose of evaluation of SAR two hand models are used homogenous model which is taken from CST-2011 package heterogeneous model which has been designed in this work. The hand design was as follows: The design started with one model given in human body Atlas [21] and shown in Fig.3. The tissues used in design were marrow, bone, blood, cartilage, tendon, muscle, and skin. The Quasi-block model is built up using cones for the ends of fingers, palm and wrist also, rectangular for wrist and palm, sphere for cartilage, and fingers, cylinders for marrow and tendon to mimic real human hand. The dimension of the hand is shown in Table I.

The model constructed from wrist, palm, and fingers. Each finger contains three bones with three joins. The palm constructed from four bone pieces joining the fingers with the wrist. The wrist constructed from cubic piece of bone shown in Fig. (4.a.). All the bones are filled with marrow tissue shown in Fig.(4.b). The bones are covered blood as shown in Fig. (4.c) .The bones are joined with the cartilage tissue shown in Fig.(4.d). Then the tendons tissues are placed on the bones Fig.(4.e). The structure is then covered with muscles Fig. (4.f). All hand construction has been packed in a skin tissue shown in Fig. (4.g). The overall designed hand is shown in Fig.(4). Properties of hand model for four frequencies are shown in Table: II.

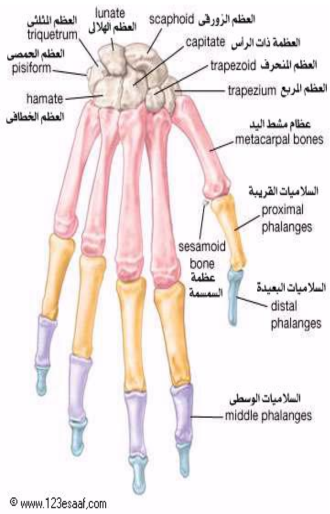
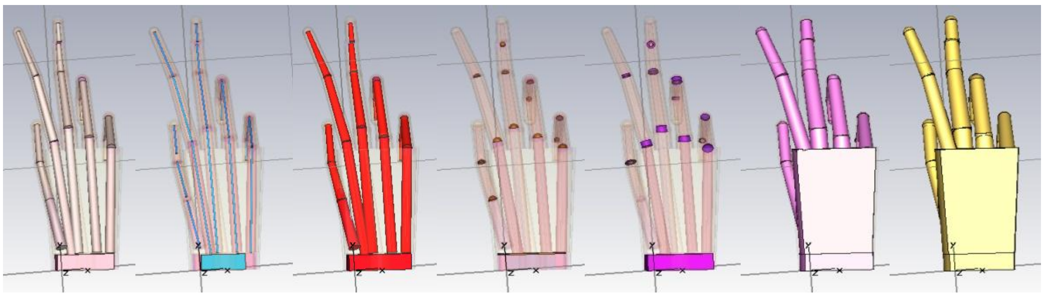


Fig.3: Hand bone structure [20].

Table - I: Designed hand model Dimensions.

Hand Dimension	mm
Thumb	100
Index Finger	170
Middle Finger	180
Ring Finger	170
Pinky Finger	130
Palm	120
Risk	50
Approx. Hand Thickness	30



a b c d e f g

Fig.4: Heterogeneous hand design steps.

Table – II: Properties of the designed hand model[22].

Material	Dielectric Properties	Operating Frequencies			
		900 MHz	1800 MHz	2100 MHz	2400 MHz
Bone	Epsilon	12.453704	11.780735	11.592	11.41
	E. Conductivity	0.143304	0.275193	0.32813	0.38459
Blood	Epsilon	61.360718	59.372261	58.851	58.347
	E. Conductivity	1.538069	2.043690	2.2614	2.5024
Skin	Epsilon	41.405334	38.871857	38.431	38.063
	E. Conductivity	0.866780	1.184768	1.3075	1.4407
Cartilages	Epsilon	42.653103	40.215481	39.535	38.878
	E. Conductivity	0.782333	1.286782	1.4939	1.7172
Marrow	Epsilon	5.504309	5.371605	5.3362	5.3024
	E. Conductivity	0.040201	0.068468	0.080159	0.092834
Muscle	Epsilon	56.879063	55.335312	53.163	52.791
	E. Conductivity	0.995364	1.437796	1.5135	1.705
Tendon	Epsilon	45.825	44.251	43.735	43.21
	E. Conductivity	0.71839	1.2008	1.4115	1.644

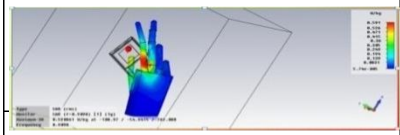
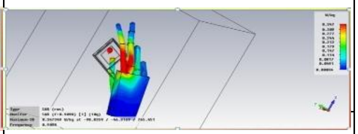
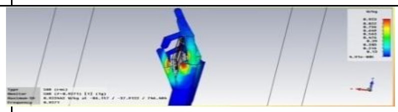
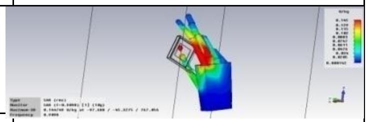
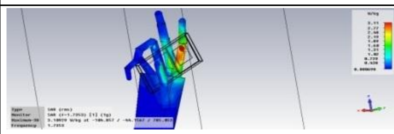
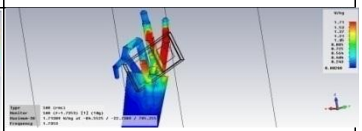
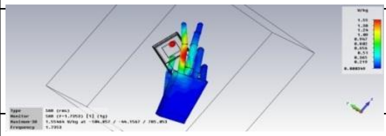
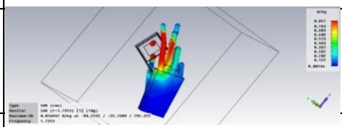
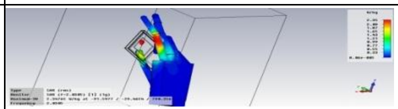
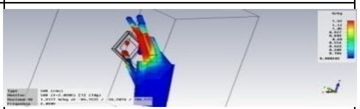
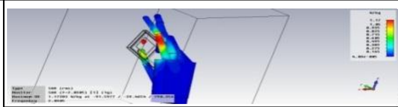
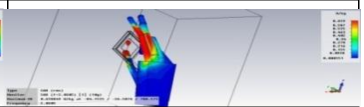
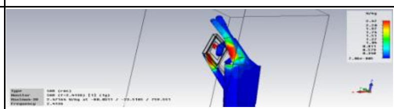
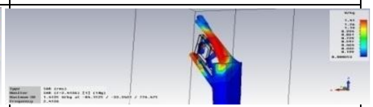
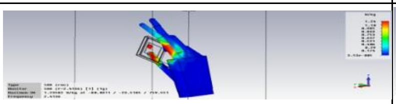
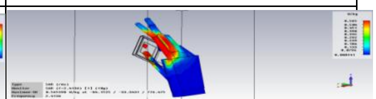
3. Tests Results

SAR evaluations tests have been done for different head and hand models, and frequencies. The SAR calculations are performed at 1g and 10g average mass. The tests are:

3.1. Designed hand with handset mobile phone test

The designed heterogeneous hand has been put with the mobile is shown in Fig.5. SAR has been measured for four frequencies and repeated for different references powers [23],[24],[25]. The test results are given in the Table: III.

Table-III: Heterogeneous hand designed with handset mobile phone.

Frequency in MHz	Reference powers	SAR 1g W/kg	SAR 10g W/kg
900	600 mW	 0.59	 0.347
	250 mW	 0.246	 0.144
1800	250 mW	 3.1	 2.01
	125 mW	 1.55	 0.856
2100	100 mW	 2.34	 1.64
	50 mW	 1.17	 0.658
2400	100 mW	 2.47	 1.43
	50 mW	 1.235	 0.565

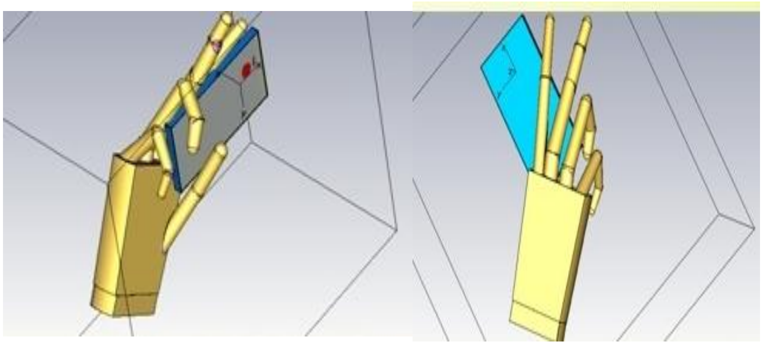
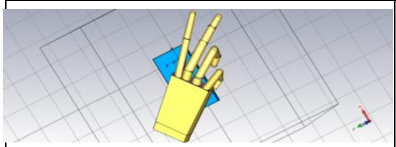
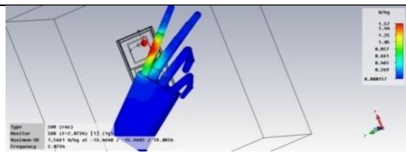
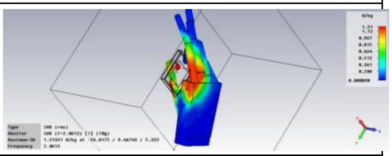
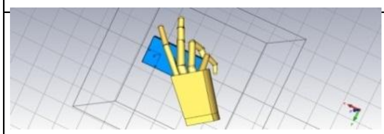
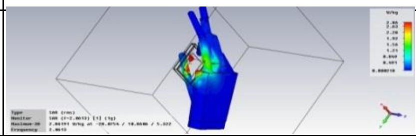
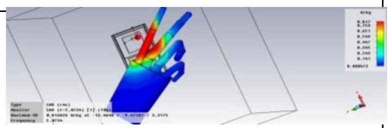
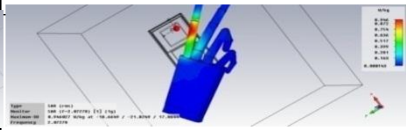
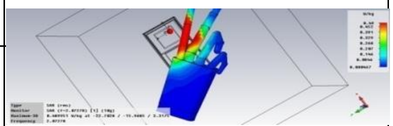
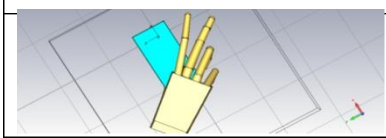
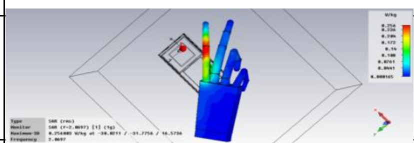
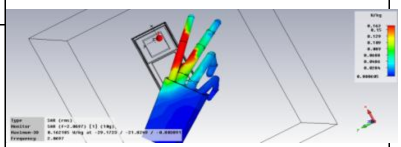


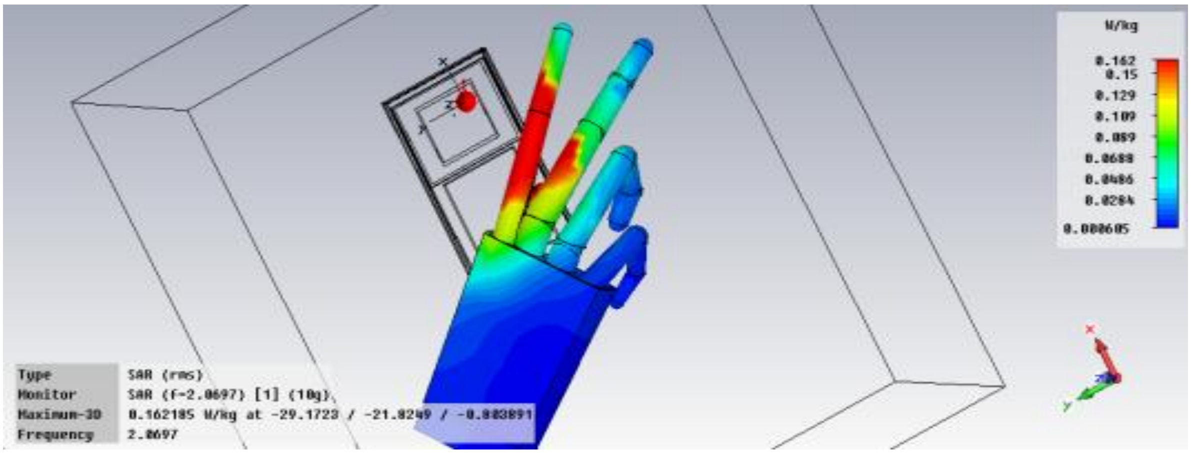
Fig.5: Heterogeneous hand design with handset mobile phone.

3.2 Hand position

The designed hand has been put with the mobile. SAR has been measured for four handling positions at (2100 MHz) with reference power 100 mW. The results of the tests are are given in Table: IV.

Table-IV: Heterogeneous hand designed with phone option.

Phone option	SAR 1g W/kg	SAR10g W/kg
		
Hand fingers and part of the palm covered antenna of handset mobile phone	2.86	1.233
		
Hand fingers covered the antenna handset mobile phone	1.566	0.8168
		
Hand fingers covered little area of the antenna handset mobile phone	0.946	0.4899
		
Hand fingers not covered the antenna of handset mobile phone	0.256	0.162



3.3. Calculate the penetration depth

Penetration depth of designed hand tissue was calculated for each tissue at frequencies (900, 1800, 2100 and 2400) MHz and the results are listed in the Table: V. by applying the equation:

$$\boldsymbol{\delta_s} = \sqrt{\frac{2}{\omega\mu\sigma_{eef}}} \qquad \dots 1$$

Where

ω: frequency (rad) / sec.

μ: the middle permeability.

σ_{eef} : middle effective connectivity (S / m).

Given the Table: V, note that the penetration depth values decreases when increasing the frequency and the relationship between them is a linear relationship, as shown in Fig.6, which shows curve the relationship between the frequency and depth of penetration for each tissue of tissues hand-designed.

Table-V: Tissue penetration depth values of designed hand

Material	Dielectric Properties& δ_s	Operating Frequencies			
		900MHz	1800MHz	2100MHz	2400MHz
Bone	σ (S/m)	0.143304	0.27519	0.32810	0.39427
	δ_s	0.049	0.025	0.021	0.018
Blood	σ (S/m)	1.53806	2.0436	2.2615	2.5449
	δ_s	0.015	0.0093	0.0081	0.0072
Skin	σ (S/m)	0.86678	1.184768	1.3075	1.4407
	δ_s	0.063	0.0216	0.0107	0.0096
Cartilages	σ (S/m)	0.78233	1.28678	1.4937	1.7556
	δ_s	0.0377	0.0117	0.0100	0.0087
Marrow	σ (S/m)	0.04020	0.068468	0.080152	0.095031
	δ_s	0.0938	0.0508	0.0434	0.0373
Muscle	σ (S/m)	0.99536	1.437796	1.6304	1.882
	δ_s	0.0188	0.0111	0.0096	0.0084
Tendon	σ (S/m)	0.71839	1.2008	1.4115	1.644
	δ_s	0.0222	0.0121	0.0103	0.0089
μ		1			

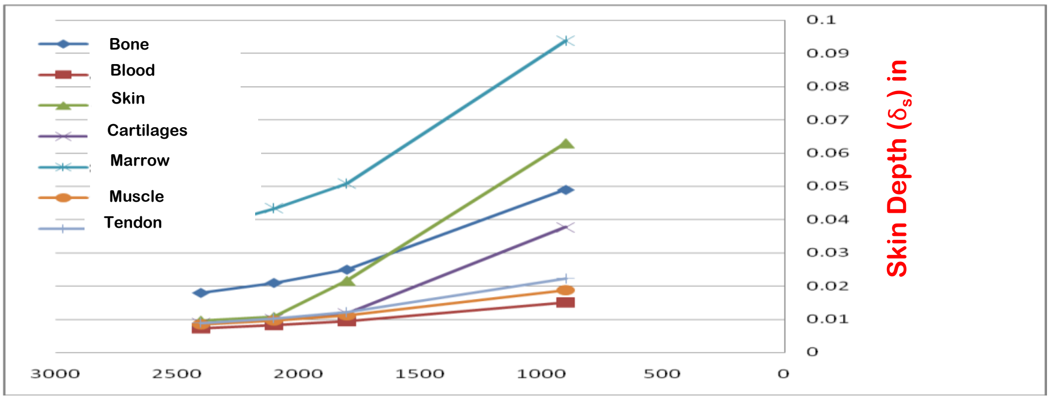


Fig.6: Chart showing the relationship between the values of penetration depth for each texture of the tissue hand designed with frequencies

(900, 1800, 2100 and 2400)MHz.

3.4. Homogenous head and hand tests

Homogenous head and hand have been put with the handset mobile phone designed in [5] is shown in Fig.7. The measurements has been represented for the four frequencies (900, 1800, 2100 and 2400) MHz and different reference powers.

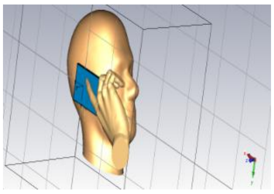
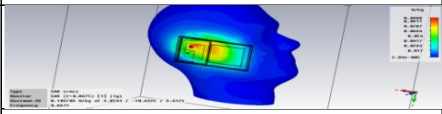
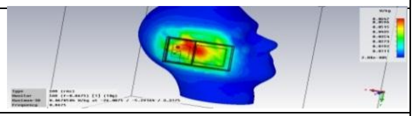
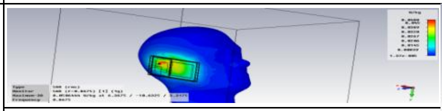
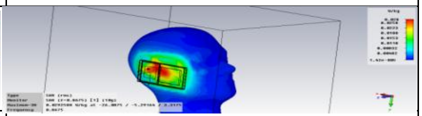
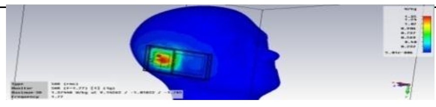
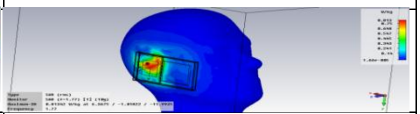
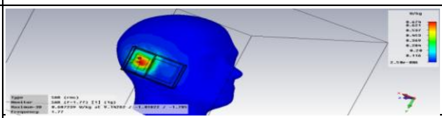
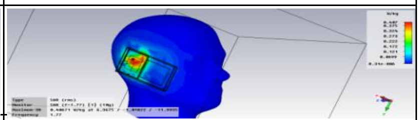
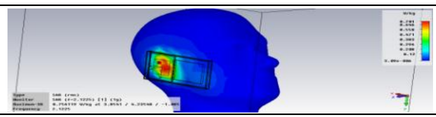
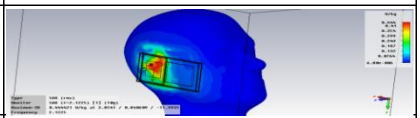
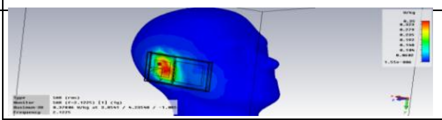
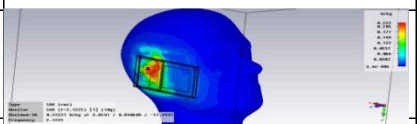
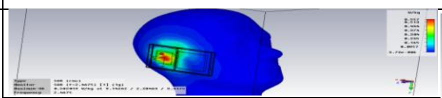
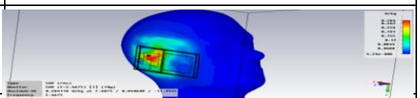
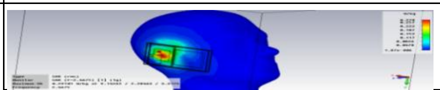
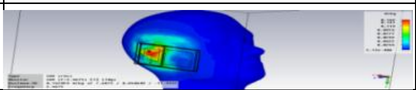
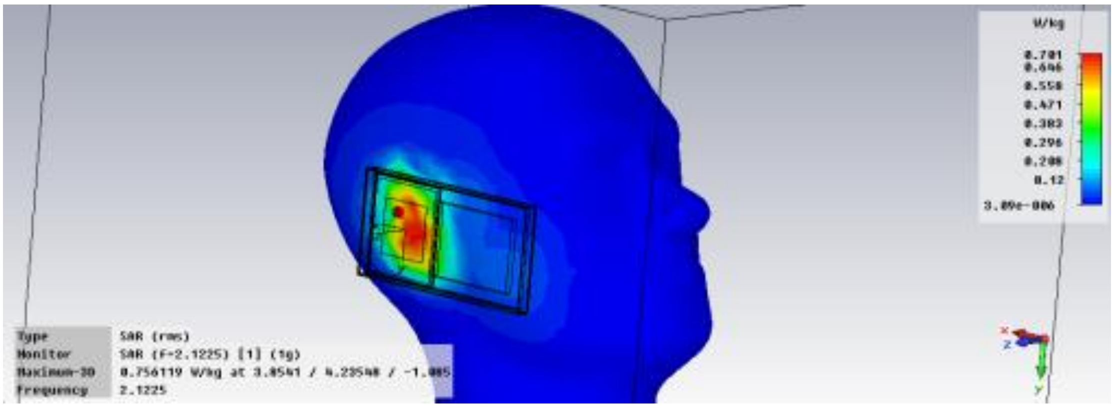


Fig.7: Homogeneous head and hand with handset mobile phone.

The SAR calculations are performed for both 1g and 10g average mass. The tests results are shown in Table: VI.

Table-VI: homogeneous head and hand with handset mobile. phone

Frequency in MHz	Reference powers	SAR1g W/kg	SAR10g W/kg
900	500 mW	 0.103	 0.0678
	250 mW	 0.05	 0.029
1800	250 mW	 1.37	 0.81
	125 mW	 0.687	 0.406
2100	100 mW	 0.756	 0.444
	50 mW	 0.378	 0.222
2400	100 mW	 0.582	 0.284
	50 mW	 0.291	 0.142



3.5. Homogeneous head and heterogeneous hand tests

Homogeneous head has been put with the heterogeneous designed hand and the mobile handset as shown in Fig.8. SAR has been measured at different reference powers for each frequency. Then the measurements has been repeated for the four frequencies (900, 1800, 2100 and 2400) MHz. The figures and results are as shown in Table: VII.

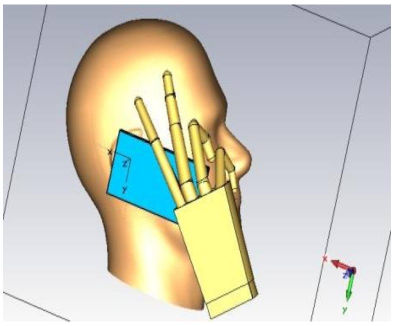


Fig.8: Homogeneous head and heterogeneous designed hand with handset mobile phone.

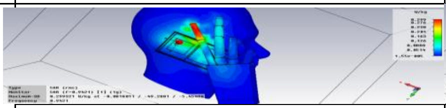
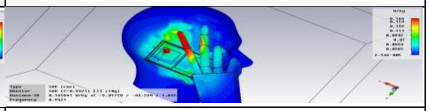
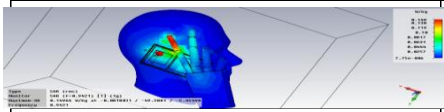
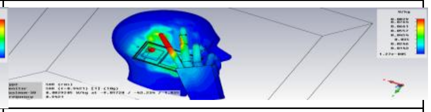
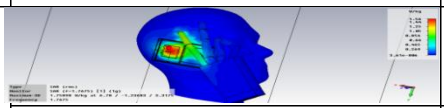
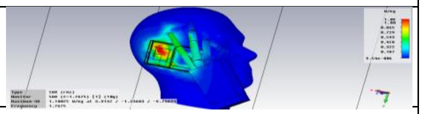
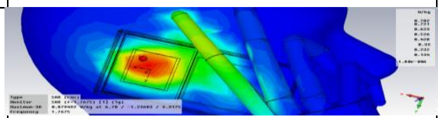
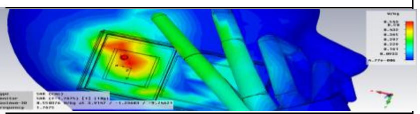
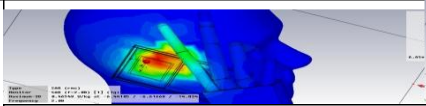
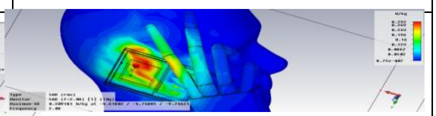
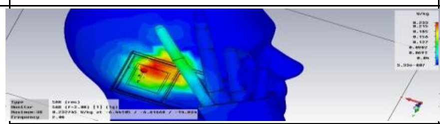
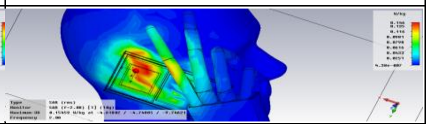
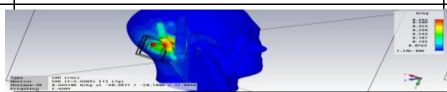
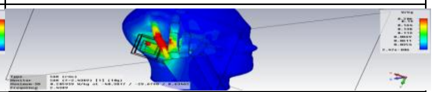
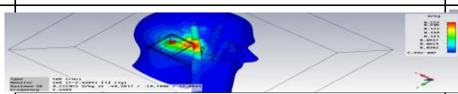
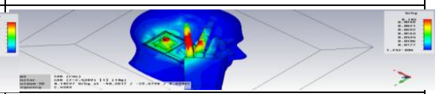
3.6. Homogenous head and hand with handset mobile phone power tests

Homogeneous head has been put with the homogeneous hand and the mobile handset. SAR has been measured for (125mw) reference power at four frequencies (900, 1800, 2100 and 2400) MHz. The figures and results are as shown in Table: VIII.

3.7. Homogenous head and hand with mobile handset phone position tests

The homogeneous head and hand model has been put with the mobile handset. The position simulation of the mobile has been changed with respect to head. The handling of the hand has been fixed. SAR has been measured for all the case for frequency 2100MHz and reference power of 100mW. The figures and results are as shown in Table: IX.

Table- VII: Homogeneous haed and heterogeneous hand with handset tests.

Frequency in MHz	Reference powers	SAR1g W/kg	SAR10g W/kg
900	500 mW	 0.299	 0.165
	250 mW	 0.14966	 0.0829
1800	250 mW	 1.758	 1.1007
	125 mW	 0.879	 0.5503
2100	100 mW	 0.465	 0.309
	50 mW	 0.232	 0.154
2400	100 mW	 0.444	 0.205
	50 mW	 0.222	 0.102

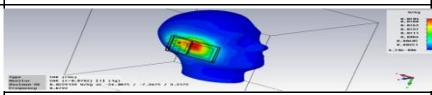
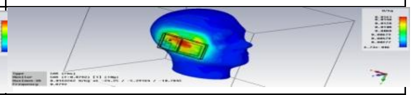
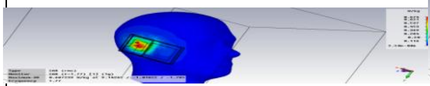
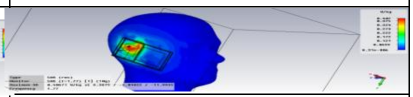
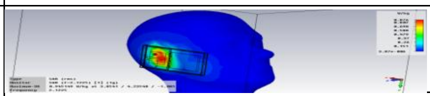
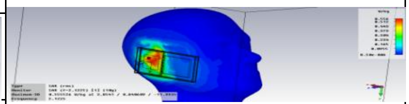
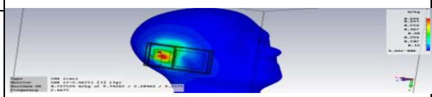
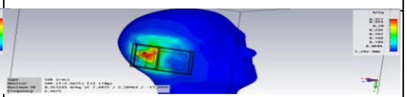
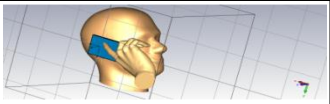
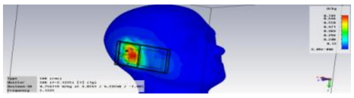
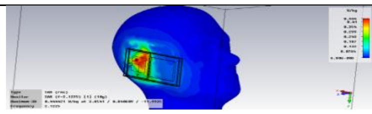
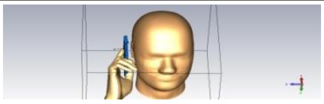
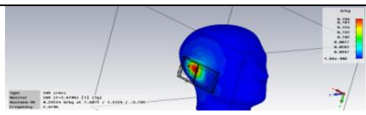
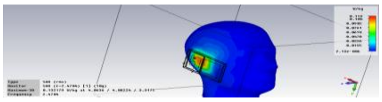
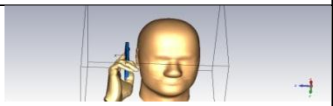
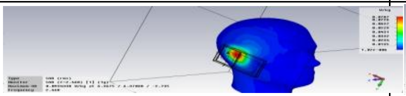
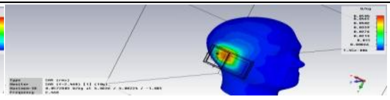
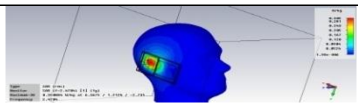
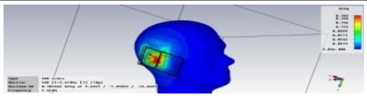
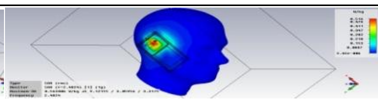
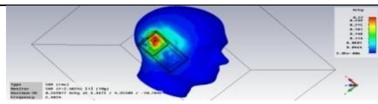
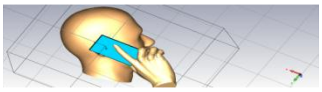
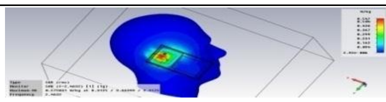
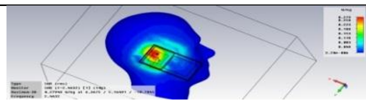
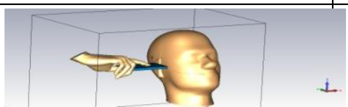
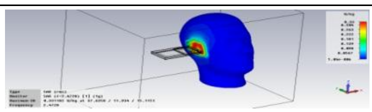
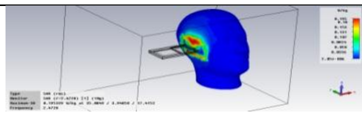
Frequency in MHz	Reference powers	SAR1g W/kg	SAR10g W/kg
900	125 mW	 0.0229	 0.0163
1800	125 mW	 0.687	 0.406
2100	125 mW	 0.945	 0.555
2400	125 mW	 0.727	 0.351

Table-IX: Homogeneous haed and hand with handset position tests

Phone option	SAR W/kg in 1g	AR W/kg in 10g
		
Normal case	0.756	0.444
		
10mmSpace between head & phone	0.235	0.132
		
20mm Space between head & phone	0.093	0. 057
		
10mm space & 10^{o}	0.35	0.182
		
Sam rotate up 10^{o}	0.563	0.269
		
Sam rotate up 15^{o}	0.575	0.279
		
Phone vertical	0.331	0.193

3.8. Heterogeneous head and hand results

The heterogeneous head (voxel) has been put with the designed heterogeneous hand and the designed handset mobile phone as shown in Fig.9. The SAR has been measured for four frequencies (900, 1800, 2100, and 2400 MHz) and for different reference powers. The results are shown in Table: X.

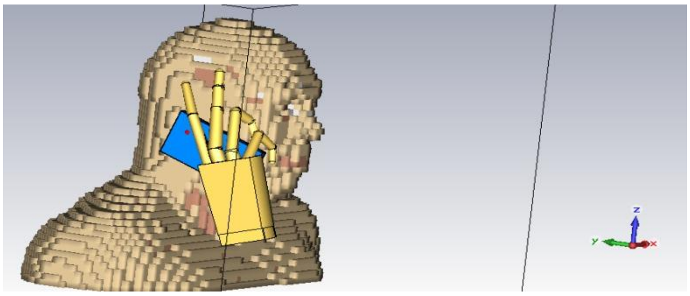
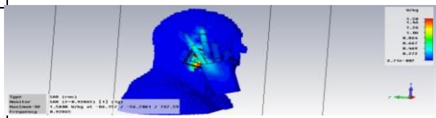
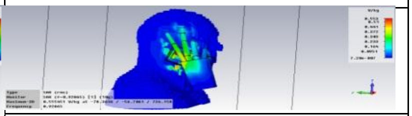
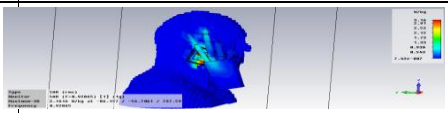
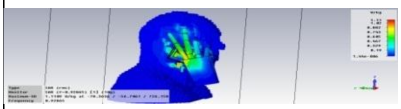
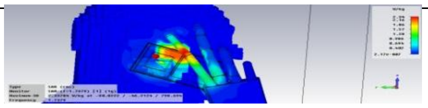
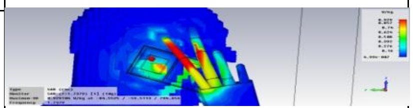
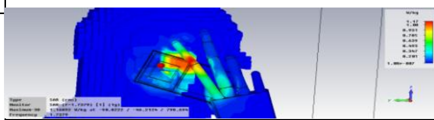
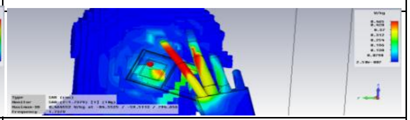
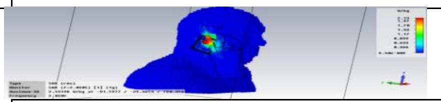
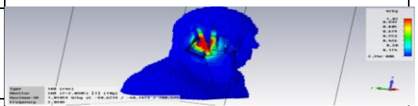
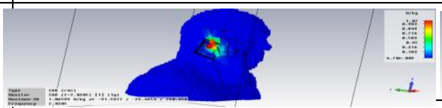
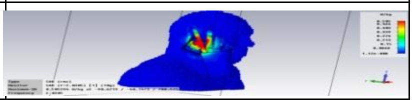
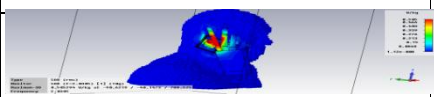
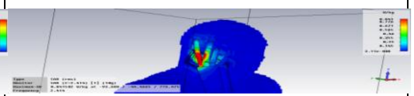
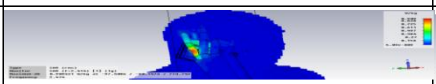
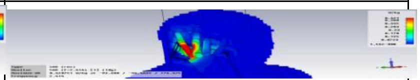
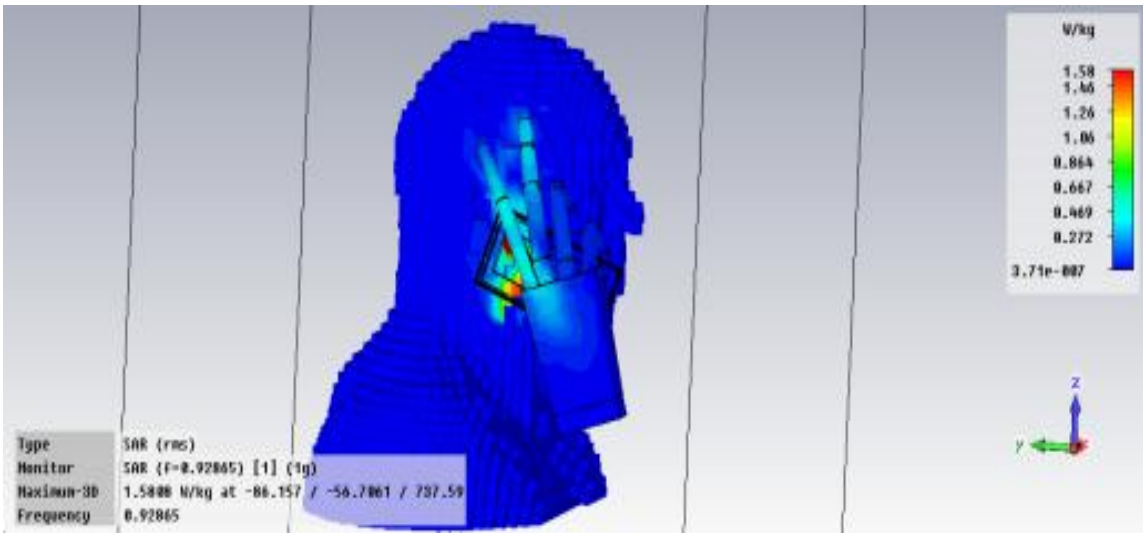


Fig.9: Heterogeneous head and hand with handset mobile phone.

Table- X: Heterogeneous haed and hand with handset tests.

Frequency in MHz	Reference powers	SAR1g W/kg	SAR10g W/kg
900	1 W	 3.16	 1.11
	500 mW	 1.58	 0.555
1800	250 mW	 2.33	 0.929
	125 mW	 1.16	 0.464
2100	100 mW	 2.13	 1.01
	50 mW	 1.06	 0.505
2400	100 mW	 1.8	 0.84
	50 mW	 0.909	 0.42



4. Results, Discussion and Comparison to previous work:-

The tests results performed in section 3 for different cases and shown in Table: III, show the values of the SAR when putting the homogenous head, hand with the mobile. For the worst handling situations, the measured SAR was maximum for frequency 2100MHz, where the gain was maximum. It was equal to 1.37W/kg for 1g average mass and 0.81W/kg for 10g average mass. The maximum average SAR was obtained at the ear.

From Table: IV, it is clear from the table that different handling of the mobile phone handset has an effect on the SAR values in the hand. The maximum SAR was for the case putting the hand on the antenna position in the mobile for frequency 2100MHz. The same phenomena has been observed for all the considered four frequencies (900, 1800, 2100, and 2400) MHz. This effect is because the hand is reflecting part of the waves to the antenna. The maximum SAR was observed in the palm, it was equal to 2.86W/kg for 1g average mass and 1.23W/kg for 10g average mass. It is clear that the SAR value for 1g average mass was more than the standard save SAR value (1.6W/kg) for 1g average mass and (2W/kg) for 10g average mass it was developed by ICNIRP(International Commission on Non-Ionization Radiation Protection).

The SAR measurement has been repeated for different reference powers of each frequency as shown in Table: V. It has been observed that the SAR maximum average value increases with the increase of the reference power. All the SAR maximum average values were within the safe standard value < 1.6 W/kg for 1g average mass and < 2 W/kg for 10g average mass.

Homogenous head and designed hand has been put with the mobile. SAR has been measured for all the considered four frequencies and different reference powers. SAR maximum average value was increasing with the increase of the frequency at same reference power. The maximum average SAR point was changing for each frequency and it is depending on radiation pattern. For example, the maximum average SAR point was at the end of the index finger for 900MHz frequency, at the antenna for frequency 1800MHz, at the ear for 2100MHz, and the maximum average SAR value returned to the lower end point of the index finger for 2400MHz.

Heterogeneous head, designed hand has been put with the mobile. SAR has been measured for different frequencies and reference powers. SAR maximum average value was increased with the increase of the frequency and reference power, in the homogeneous head. The SAR maximum value point was changing. For 900 MHz frequency, the maximum SAR point was at the middle of the thumb finger independent of the reference power. For 1800, 2100, and 2400MHz, the point was at the middle of the index finger.

Table: IX shows the results of homogeneous head, hand with different mobile positions. The results also show that increasing the angle between the mobile handset and the head by 10^o, SAR reduced by 30%. Moving the mobile with 10mm, away from the head SAR had reduced by 70%, and 20mm, SAR had reduced by 80%. From this table we conclude that the SAR value gradually less the greater the distance between the ear user and the mobile device and the relationship between the relationships is linear as shown in the chart of the relationship between the distance between the device and the ear user with the SAR value and shown in Fig.10.

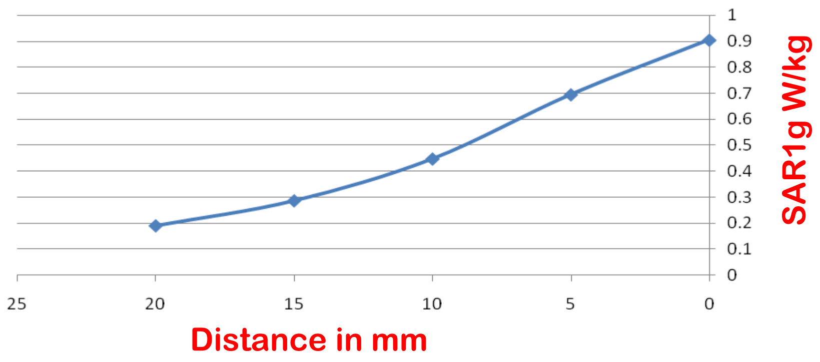


Fig.10: graph of the relationship between the value of SAR1g and the distance between the mobile device and the ear user.

5. Conclusion

In this work, the effects of RF wave radiated from the handset mobile antenna on human hand and head wave were investigated. A homogeneous and heterogeneous head and hand models were used to evaluate maximum average SAR distribution and values. The evaluation was performed for four frequencies (900, 1800, 2100, and 2400) MHz. The maximum average SAR was measured for the multi layers designed hand with the mobile. The results observed that maximum SAR point was in the index finger for all the considered frequencies.

SAR was measured for the homogeneous and heterogeneous head, hand and mobile handset. The maximum average SAR point was shifting toward the head, by increasing the frequency up to 2100MHz, where the maximum average SAR point was at the hand more strictly at the fingers for 900MHz and at the mobile for the 1800MHz then it appeared at the ear for the 2100MHz. All the measured values of the SAR were within the standard piece limit value except for 2100MHz and reference power 100mW, 2400MHz for the same reference power.

The SAR appeared to be inversely proportional with the distance between the mobile end the head, where SAR was reduced by 70% for moving the mobile with 10mm away from the head, and by 80% for moving the mobile by 20mm away from the head.

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دراسة تأثير الترددات الراديوية للهاتف النقال على صحة الإنسان

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المستخلص

العمل الحالي يشمل دراسة وتقييم معدل الامتصاص النوعي(SAR) للموجات الكهرومغناطيسية في جسم الإنسان (الرأس واليد). الترددات الراديوية(RF) تنبعث بشكل طبيعي من أجهزة الهواتف النقالة الواسعة الانتشار بشكل طبيعي في الآونة الأخيرة بين الأعمار المختلفة من البشر. هذا الموضوع جذب انتباه الباحثين في الآونة الأخيرة.

عملية التقييم تحتاج وجود عناصر ثلاثة رئيسية: رأس ويد الإنسان بالإضافة إلى جهاز الهاتف النقال. كلا النموذجين المتجانس(SAM) للرأس واليد والغير متجانس للرأس(voxel) استعملت في هذا البحث. يد الإنسان تم تصميمها من سبعة طبقات من قبل الباحث لتكون قريبة للنموذج الغير متجانس لليد الحقيقية. جهاز الهاتف النقال تم تصميمه من قبل الباحث فيه هوائي رقعي يعمل بأربعة حزم ترددية MHz(900,1800,2100,2400). عملية التقييم أجريت لمواضع وطرق مختلفة لمسك الجهاز أثناء الاستخدام نسبة إلى المحور العمودي لرأس المستخدم لكلا النموذجين المتجانس والغير متجانس.

أظهرت النتائج بأن قيم معدل الامتصاص النوعي أكثر واقعية في النماذج الغير متجانسة مقارنة مع النماذج المتجانسة. أعظم قيمة (SAR) كانت في إصبع السبابة لكل الترددات المعتمدة وإن قيمة(SAR) تقل بمقدار 70% عند ابتعاد الجهاز عن الرأس بمقدار(10) ملم وتقل بمقدار 80% إذا ابعد الجهاز بمقدار (20) ملم عن رأس المستخدم. تم استخدام النماذج الحاسوبية باستخدام البرنامج CST لإجراء التقييم والدراسة.

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