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DESIGN AND DEVELOPMENT OF A DUAL LOOP HEPTA-BAND ANTENNA FOR WIRELESS COMMUNICATIONS

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ABSTRACT— A metal-rim which is kept unbroken acts as a Hepta-band dual loop antenna for the wireless communications. This metal-rim is the greatest feature of the proposed multiband antenna. The dual-loop antenna provides an Hepta-band coverage of the mobile and wireless applications. The multiband antenna covers the operating bands of GSM900/ GPS/UMTS/Bluetooth/WiFi/ WiMax/ LTE and other effectively. This simple multiband antenna covers the broadband and public safety band applications. The proposed antenna dramatically operates at high frequencies. The unbroken outer metal rim posses the height of 5mm and the total circuit system board is of 130x70. In the system board we have ground & no-ground portions. The circuit board has two no-ground portions which are set at the top edge of about 10x70 mm^2 and bottom edge of about 5x70mm^2. System ground of 115x70 mm^2 is kept between the two separate non-ground parts. There is a connection from the system ground to the metal rim which is unbroken is made via a small ground patch. Thus this patch will divide the metal rim into two effective stripes which forms a dual loop character. This dual loop antenna provides multiband of operating range between (0.9 to 4.9) GHz by combining the multi resonant characters of the antenna. The Specific Absorption Rate(SAR) is simulated and calculated. Thus the dual-loop antenna has the SAR less than 1.6 W/Kg effectively. The complete and detail design functions of this multiband dual loop antenna are described with simulation results which are also shown and discussed clearly.

INDEX TERMS— multiband dual loop antenna, metal rim, Hepta-band, SAR, LTE applications.

I. INTRODUCTION

In last the smart phones have entered into a rapid development period. They have become the main communication tool. A smart phone with a metal rim which made unbroken is been proposed. The metal rim not only provides the greatest mechanical strength for the extension of the service life of smart phone, they also can posses a wonderful appearance that is very desirable to the consumers. To provide the wide and large bandwidth, we have so many efficient techniques like the coupled-fed, matching network and reconfigurable techniques.

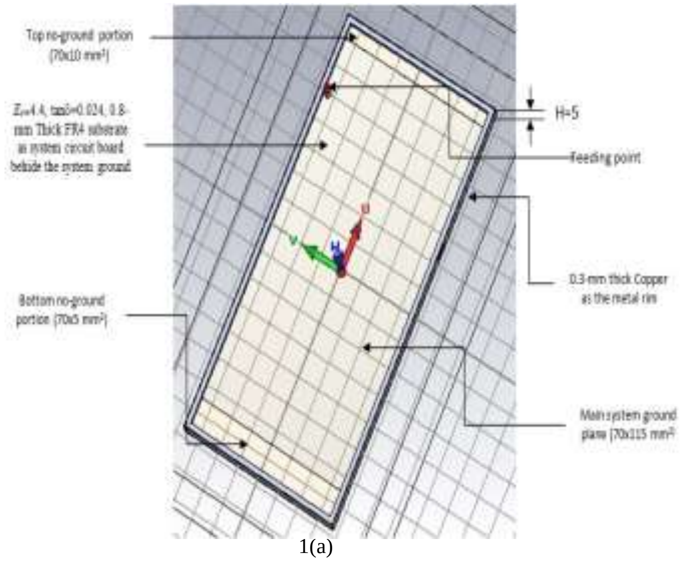
A dual-loop antenna of an capable of providing Hepta-band operations in the smartphone applications is done and proposed. And there is a small coaxial feed line which is fed directly and it is been connected by a mini ground patch to the system of ground at the middle if the circuit-board. Consequently the rim is been divided into two stripes and by combining the ground and the two stripes. The highest quality of this developed antenna is the maintenance of the integrity of the outer rim. In the hand effect antenna two gaps patches and three ground patches are inserted. this can reduce the rim effect. And to avoid the ground patches slot antenna is been used. But the slot antenna gives only the few GHz of band. So to avoid all the above consequences we are introducing the Hepta-band antenna.

Compared with some other promising antennas whose bandwidth is widened by utilizing matching network , coupled feeding process requiring additional board area and cause insertion loss, the proposed simple dual-loop antenna structure without any matching network is designed which simplifies the difficulty of antenna tuning & guarantee its low fabrication cost and high radiation efficiency.

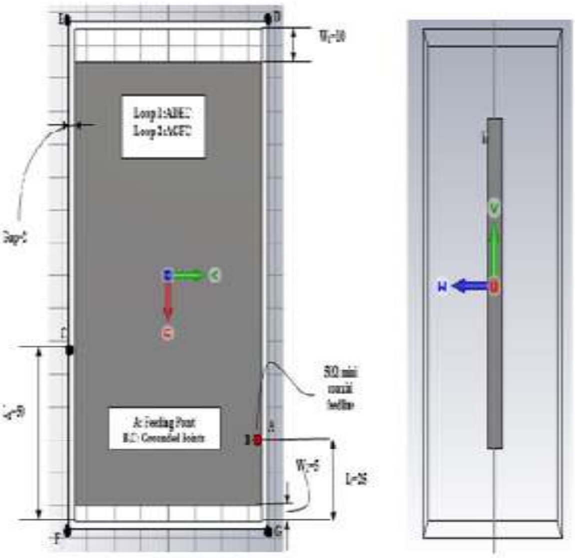
II. ANTENNA CONFIGURATION

The Hepta-band antenna has the integrity of the rim and reduced the return loss. Fig.1 (a) shows about the geometry of Hepta-band dual-loop antenna of smart phones. In Fig. 1(b) the optimized structure and the detailed dimensions are given. Thus in the Fig. 1(a), in the circuit board we have the FR4 substrate of 0.8mm thick with the relative permittivity 4.4 & loss tangent 0.024. The total outer coverage of the rim antenna is 130x70 mm and the height if the unbroken rim is 5 mm. In this proposed antenna two non-grounded portions are introduced as 10x 70 mm and 5x 70 mm in the top point and the bottom point edges of the system board. The system board has the thickness of 0.3 mm.

There is a small distance between the system board and the outer rim as 2 mm gap. Aground plane with the length and width of 115mm and 70 mm in between the non-grounded parts. point as point B by a small co-axial line. A 25mm of distance is been given between them. point. Same as this, a 50mm of distance is been given between the grounded patch and the edge bottom point. Thus by this process two loops are formed to give the proposed antenna functions. The Loop-1 has the geometrical length of about 260 mm generated at 0.68GHz.the resonance modes are generated according to this process. The Loop-2 length is of 156 mm and generated at 1.56GHz respectively.



1(a)



1(b)

Fig 1: Hepta-band Antenna configuration (a)Geometry representation of metal rimmed antenna (b) Detailed dimensions of the antenna(front & side views)(Unit: mm)

Thus seen from the figure 1(b) the antenna is connected to a feeding point as point A and to the ground

III. DESIGN PROCESS AND PARAMETER STUDY

The proposed antenna is designed using the CST Microwave 2014 tool. The materials for substrate (Air, FR4, vaccum & PEC) are selected. Aligning the Coordinate systems (u,v,w) with faces and edges is very much important for the designing the proposed dual loop Hepta-band antenna. The components like ground, inner shield, outer shield, ground patch, feed line, no-ground portions are created and imprinted at the substrate. The ports are selected for the transmission of the power and field monitoring is done. Simulation by the transient solver. The results are obtained with respective to the required frequency.

The parameters are return loss, radiation pattern, VSWR and the gain. The operating frequencies are 0.9GHz, 1.5GHz , 2.1GHz , 2.4GHz, 3.5GHz, 4.2GHz and 4.9GHz. Thus the gain is obtained with better performance. Reflection coefficient (dB) shows that when all switches are on it is below -10 dB in frequency range 0.9 GHz to 4.9 GHz. The S- parameter, VSWR their respective gains are simulated. The s-parameters is obtained with the frequencies of 0.9GHz, 1.5GHz , 2.1GHz , 2.4GHz, 3.5GHz, 4.2GHz and 4.9GHz.

Return loss is the difference between forward and reflected power in dB. The return loss is given by P_R/P_T. For maximum power transfer, the return loss should be as small as possible, the return loss should be as large a negative number as possible. The most common case for measuring and examining VSWR is when installing and tuning transmitting antennas. When a transmitter is connected to an antenna by a feed line, the impedance of the antenna and feed line must match exactly for maximum energy transfer from the feed line to the antenna to be possible. This is been designed in the CST microwave tool software and obtains the higher gain than the other antennas

IV .SAR (Specific Absorption Rate)

The SAR is simulated by using the phantom head model along with the proposed dual-loop multiband antenna. The simulation is done with SAR values for 1-g head tissue and 10-g head tissue. These are provided by the CST version 2014. In the design simulation, the proposed multiband antenna is placed very close to the ear of the phantom head model with the distance of 1mm. The inclination angle is 60 degree of vertical line with the input power for the testing of SAR is 24dBm and 21dBm respectively. The simulated SAR values are obtained below 1.6 W/Kg. for the 1-g and 10-g tissue which is effectively acceptable for the mobile and wireless applications.

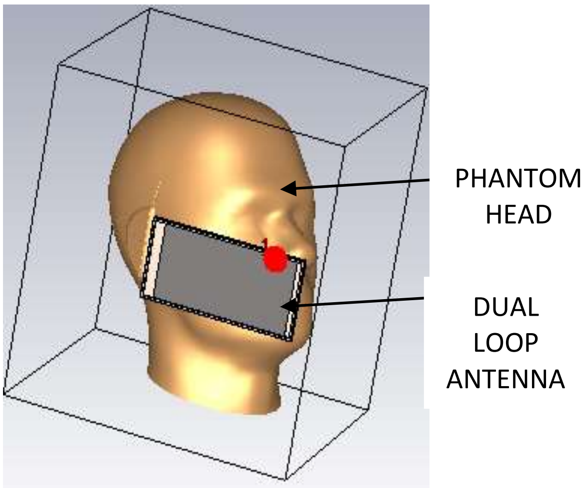


Figure 2 Phantom head model with proposed multiband antenna

FREQUENCY (GHz)	SAR OF REFERENCE ANTENNA	SAR OF PROPOSED DUAL LOOP ANTENA	
	1g(W/Kg)	1g(W/Kg)	10g(W/Kg)
0.9	1.47	1.25	0.96
1.5	0.80	0.80	0.6
1.8	0.89	1.36	1.19
2.1	1.24	1.58	0.89
2.4	1.27	1.53	1.04
3.5	Not determined	1.43	0.59
4.2	Not determined	1.29	0.56
4.9	Not determined	1.02	0.45

Table 1.1 SAR COMPARISON

The SAR of the proposed antenna is compared with the reference paper of mobile antenna which is shown in table1.1. Thus the proposed antenna has the SAR values less than 1.6 W/Kg which is suitable for the wireless applications.

V.RESULTS AND DISCUSSION

Performance of proposed antenna, was investigated by using the CST Microwave Studio 2014 software . Reflection coefficient (dB) shows that when all switches are on it is below -10 dB in frequency range 0.9 GHz to 4.9 GHz. The S- parameter, VSWR their respective gains are simulated.

A. S- PARAMETER: (RETURN LOSS)

The S-parameters is obtained with the frequencies of0.9GHz, 1.5GHz, 2.1GHz, 2.4GHz, 3.5GHz, 4.2GHz and 4.9GHz. Return loss is the difference between forward and reflected power in dB. The return loss is given by P_R/P_T. For maximum power transfer, the return loss should be as small as possible, the return loss should be as large a negative number as possible.

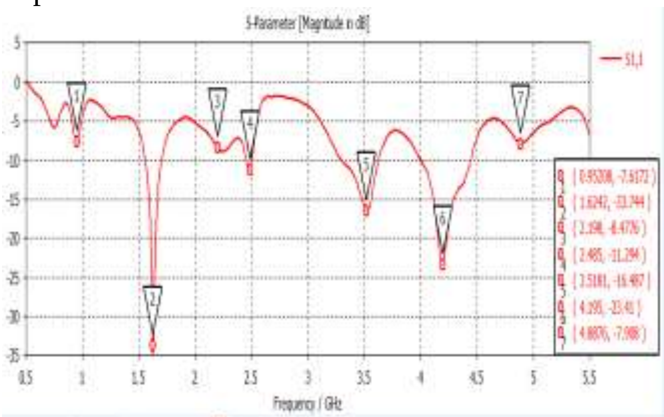


Figure 3.1 S-parameter of multiband antenna

B. VSWR

The most common case for measuring and examining VSWR is when installing and tuning transmitting antennas. When a transmitter is connected to an antenna by a feed line, the impedance of the antenna and feed line must match exactly for maximum energy transfer from the feed line to the antenna to be possible.

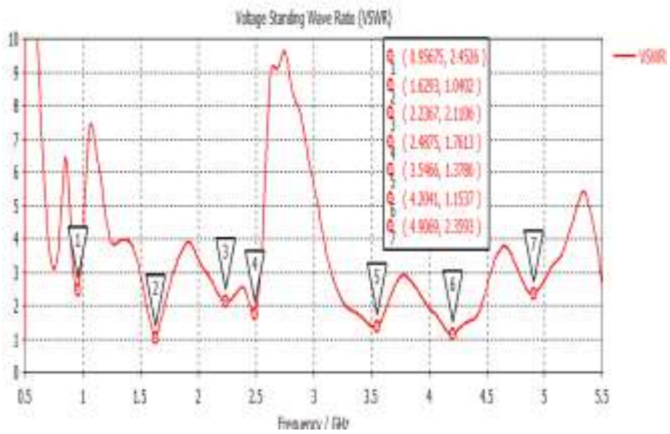


Figure 3.2 VSWR

C. RADIATION PATTERN: (3D)

The radiation pattern for the proposed dual loop antenna with the operating band of (0.9- 4.9)

a) 0.9 GHz

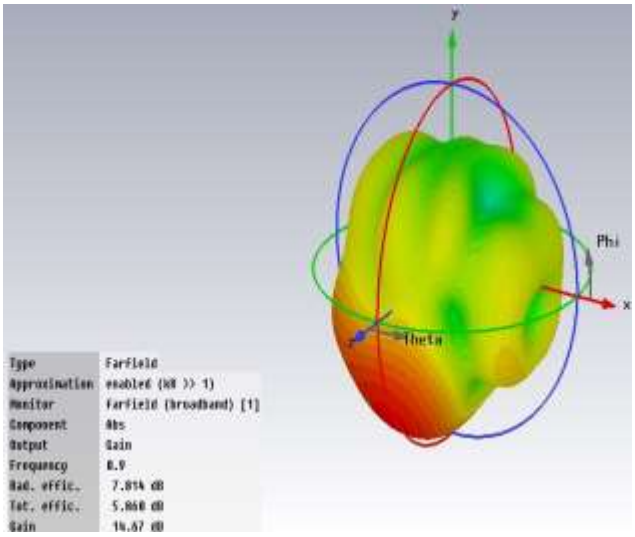


Figure 3.3a: 3D- Radiation pattern at 0.9 GHz

b) 1.5 GHz

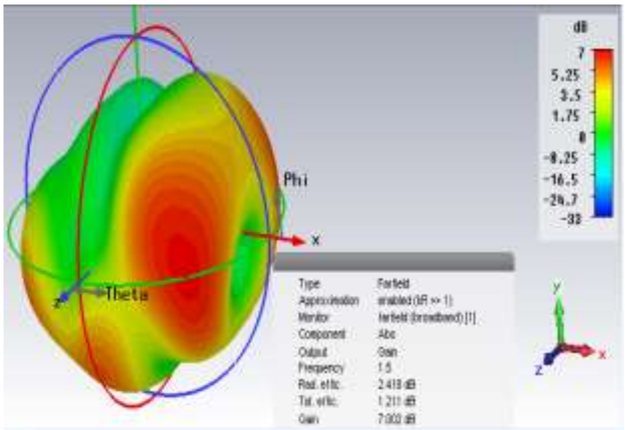


Figure 3.3b: 3D- Radiation pattern at 1.5 GHz

c) 2.1 GHz

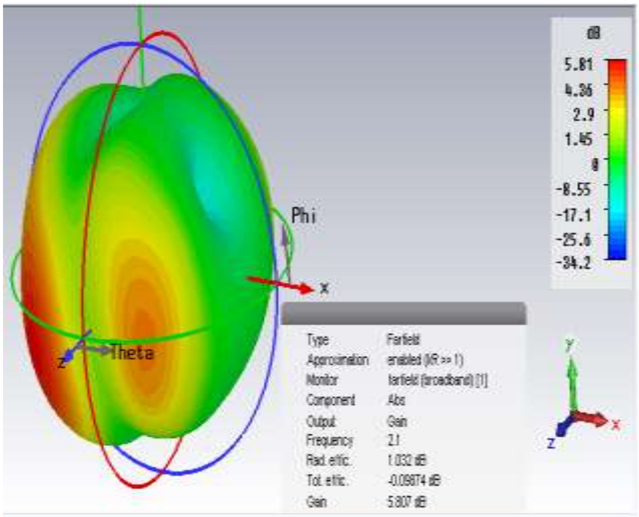


Figure 3.3c: 3D- Radiation pattern at 2.1GHz

d) 2.4 GHz

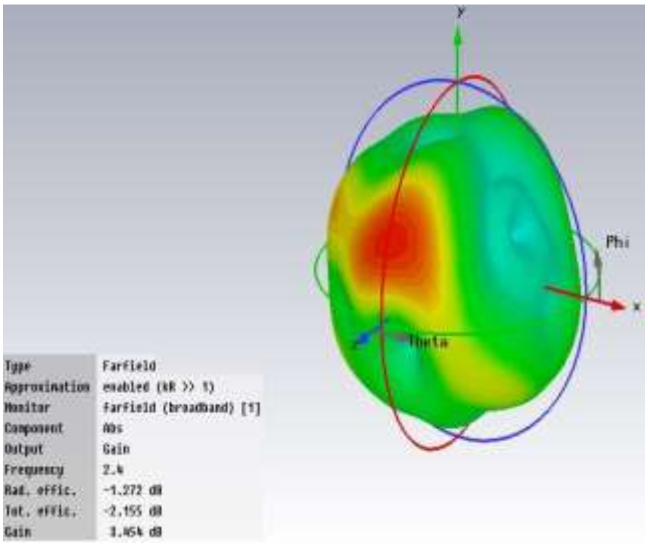


Figure 3.3d: 3D- Radiation pattern at 2.4 GHz

e)3.5 GHz

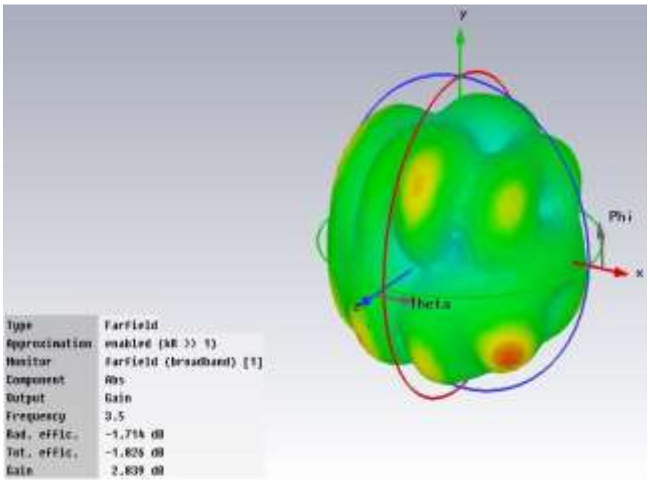


Figure 5.3d: 3D- Radiation pattern at 3.5 GHz

f) 4.2 GHz

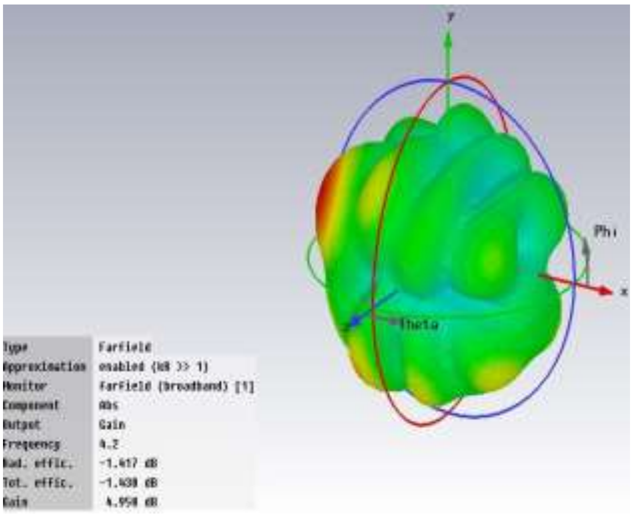


Figure 5.3e: 3D- Radiation pattern at 4.2 GHz

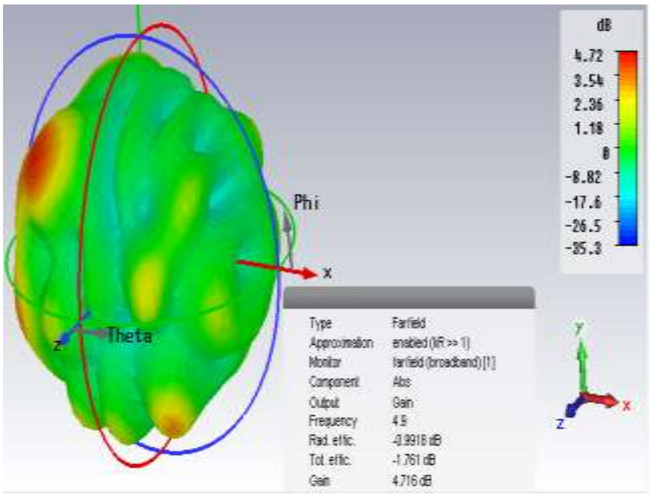


Figure 5.3e: 3D- Radiation pattern at 4.2 GHz

The respective gain is obtained as 14.67dBi, 7dBi, 5.81 dBi, 3.45 dBi and 3.83 dBi 4.95dBi and 4.72 dBi.

D. SAR Simulations

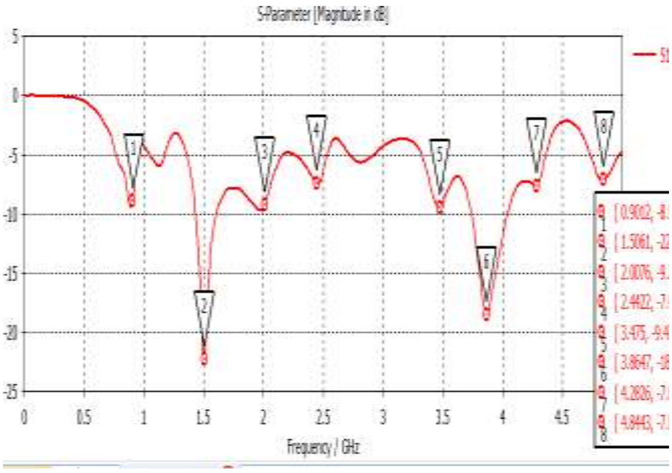


Figure 3.4 S-parameter of multiband antenna

SAR for 1g :

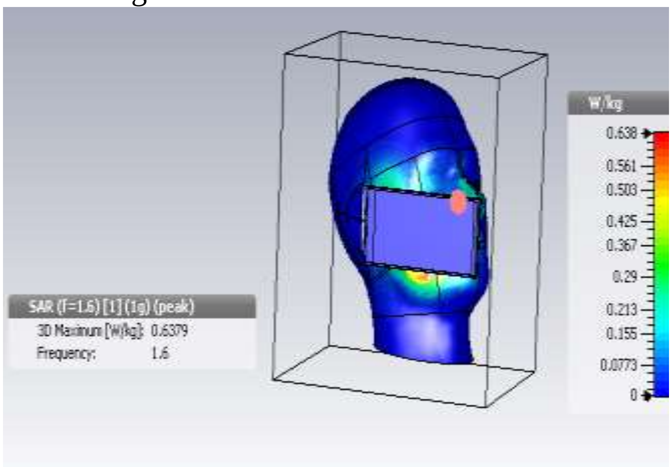


Figure 3.5 SAR of multiband antenna of 1g at 1.6GHz

SAR for 10g:

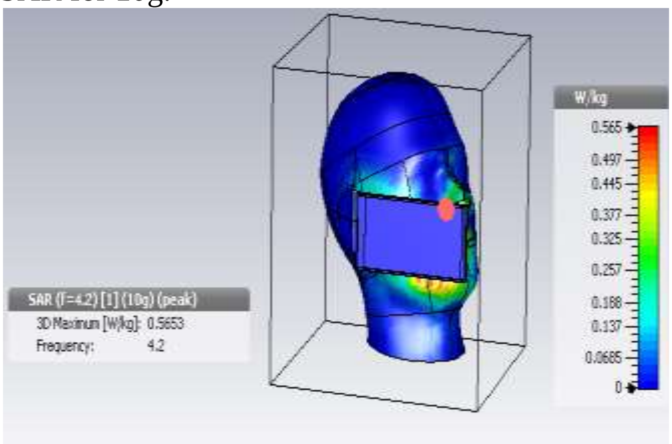


Figure 3.5 SAR of multiband antenna of 10g at 4.2 GHz

The table 2.1 gives the clear view of how the proposed antenna operates better than the other conventional antennas. They obtains a very high efficiency and obtains better gain with higher operating bands.

Reference	Proposed antenna	Slot antenna for mobile	Gps & wlan pifa antenna	Multiband antenna for mobile
INTEGRITY (of metal rim)	YES	NO	YES	YES
ANT.AREA (mm^2)	1886	875.75	325	600
TOTAL AREA(mm^2)	130 X 70	115 X 56.5	130 X 80	120 X 60
OPERATING BAND (ghz)	0.9-4.9	0.82-2.17	1.5-2.48	0.82-2.17
Total efficiency	60-80	60-70	50-60	54-79

Table 2.1 Comparison of results with conventional antennas

V.CONCLUSION

The concept of using dual loop as a cellular antenna in mobile phones has been studied. The newly proposed design has a different radiating mechanism, as compared to the conventional antennas. It has a longer electrical length so that it can provide lower concentration of surface current distribution. The structure has good impedance matching and has the ability to operate at multiple frequency bands simultaneously. The hepta-band dual loop metal rimmed antenna operations in the applications of smart-phones is developed in this paper. The antenna structure is been designed and developed without any matching network which simplifies the antenna tuning difficulty and high radiation efficiency. This also guarantees its low fabrication cost. The proposed antenna provides wide operating band (0.9 to 4.9) GHz. The results consist of the S parameter, total efficiency antenna peak gain ,VSWR and SAR which can meet the effective requirements for smart-phone applications.

In future the structure of the antenna is modified and designed to obtain Hepta-band with high gain and performance. The analysis and simulations are done to measure the S parameter, total efficiency antenna peak gain and VSWR. Then a prototype is fabricated and tested by the Network Analyzer.

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