Reduction of Specific Absorption Rate in Multiband Antenna for Mobile Applications

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Abstract: ***Technology has grown to its peak and mobile phone plays the major role in today's life. Antenna is an important device used for communication in mobile phone. Multiple antennas are used in mobile phones for each application and also the specific absorption rate (SAR) is high in these antennas that affect the human brain. The FCC limits for public exposure from cellular telephones is the SAR level of 1.6 watts/kilogram. To decrease the number of antennas in mobile phone and to reduce the SAR in the mobile phones, in this work a PIFA with Spiral slot and DGS is designed. The antenna design, simulation and the SAR calculation is done in HFSS. PIFA structure reduces the backward radiation thereby reducing the SAR value. The antenna operates in multiband (GSM 1800, UMTS) and also due to PIFA structure the SAR rate of the antenna is reduced to 1.1 watts per kilogram that meets the FCC requirement.***

Keywords: Defected ground structure (DGS), multiband antenna, planar inverted-F antenna (PIFA), and slotted antenna, specific absorption rate (SAR).

1. Introduction

Today mobile phone plays a major role in day to day life. It has become one of the necessities in our life but it produces harmful radiation that affect the human brain. So in this paper a PIFA along with spiral slot and DGS structure is designed. The antenna also operates in multiband.

A multiband inverted-F antenna for mobile handsets has a independent control on the resonant bands for UMTS, m-WiMAX and 5GHz WLAN. A current distribution on the radiator is the controlling parameter of the antenna [1]. To improve the bandwidth at both low and high frequencies slotted ground plane is used without increasing the size of the antenna. PIFA with multiple slots on a ground plane covering the GSM850 and GSM900 bands [2]. Electromagnetic bandgap structure acts as a perfect magnetic conductor surface because it has a bandgap capability and it reduce the undesired radiation from an antenna. The EBG also reduce the electromagnetic waves that travel towards the human head [3]. Some material like ferrite has equal permittivity and permeability that is used to low specific rate (SAR) antenna. The ferrite material coating enables better control to be exerted over the antenna fields when placed close to the handset ground plane, and thus contributes to positioning an axial pattern null towards the head and having a very low SAR [4]. Further techniques for improve the bandwidth and reduce the SAR are discussed in [5]-[6].

2. Proposed System

The resonant frequency of a planar inverted-F antenna (PIFA) is approximated by the Equation (1)

$$F_r = \frac{C}{4(L_p + W_p - W_s)} \quad (1)$$

$$C = \frac{C_0}{\sqrt{\xi_r}} \quad (2)$$

Where, $C_0 = 3*10^8 \, m/s$, L_p is length of the patch, W_p is width of the patch, W_s is width of the substrate.

The material used for substrate is FR-4 with a dielectric constant of 4.4, a loss tangent of 0.02 and a substrate height of 1.57 mm. The proposed antenna has a very small size and is physically thin. The total volume of the radiator is $30*38*6mm^3$, while the overall volume of the antenna including the ground plane is $40*40*6mm^3$.

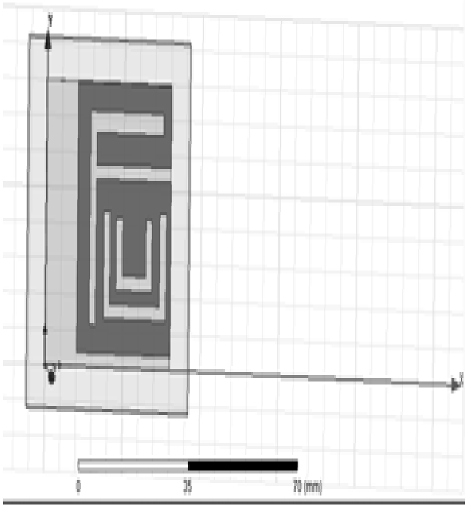
High Frequency Structure Simulator (HFSS) is used for analysis of the antenna.

2.1 PIFA with U shape slot and DGS

The basic PIFA is modified by a U slot and DGS. The modified antenna is shown in the figure 1(a). It consists of two U slots. The dimension for the slots are theoretically calculated and designed. The U slot is designed to make the antenna to resonate at UMTS band.

2.2 PIFA with spiral slot and DGS

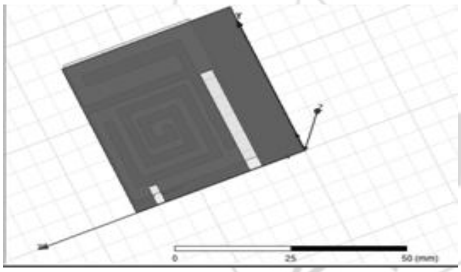
The proposed antenna has spiral slot along with the PIFA patch. This spiral slot is introduced to make the antenna resonate at multiband that is suitable for mobile application. PIFA with spiral slot and DGS are shown in Figure 1(b).



(a)

Table 1: Phantom material

Tissue Material	*Permittivity*	*Conductivity (s/m)*	*Tissue density* $\left(\frac{Kg}{m^3}\right)$	*Thickness (mm)*
Skin	38.1	1.44	1100	0.5
Fat	5.29	0.102	920	0.5
Bone	11.41	0.385	1850	3
Dura	42.1	1.64	1050	0.5
CSF	66.3	3.41	1060	0.5
Brain	42.6	1.48	1030	30



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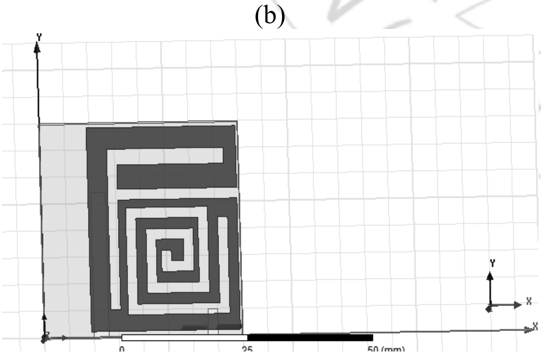

(c)

Figure 1: Designed antennas. (a) PIFA with U slot. (b) Defected ground structure. (c) PIFA with spiral slot.

2.3 Design Procedure for SAR Calculation

For calculating SAR for mobile phone the head phantom model is first created. The head phantom model consist of six layers that are present in our human head starting from the outer layer skin to the inner most layer brain.

The Table 1 contains the value of permittivity, conductivity, tissue density and thickness of each tissue layer.

3. Results and Discussion

The two antennas are designed and simulated using ANSYS HFFS. The result of the three antennas is discussed below.

3.1 PIFA with U shape slot

The antenna resonates at 3.3 GHz with return loss of -25 dB which is the UMTS operating frequency as shown in Figure 2. PIFA reduces the backward radiation and so the SAR value is reduced.

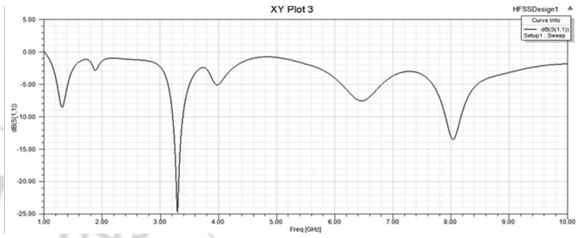

Figure 2: Return loss

3.2 PIFA with spiral slot

The antenna resonates at two bands due to the spiral structure introduced. It resonates at GSM 1800 with return loss of -35 dB and UMTS band with -28 dB. These two bands are used for voice communication in mobile phone. GSM 1800 is the 2G standard and UMTS is 3G standard for mobile phone. Figure 3 shows the return loss of the PIFA with spiral slot antenna

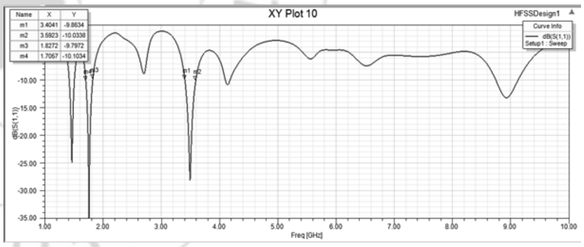

Figure 3: Return loss

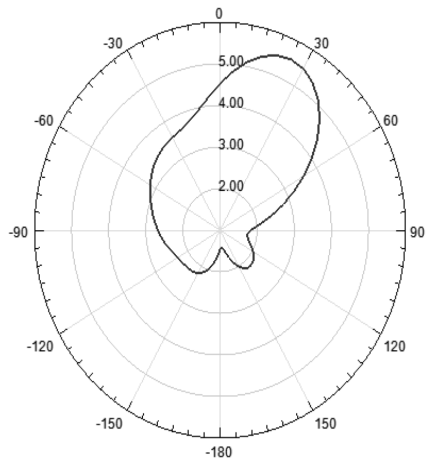

Figure 4: Radiation pattern

Figure 4 shows radiation pattern of PIFA with spiral slot and DGS structure. It has a wide beam width than the other antenna. The main lobe has the maximum radiation towards 30 degree and the side lobe is suppressed.

3.3 SAR Calculation

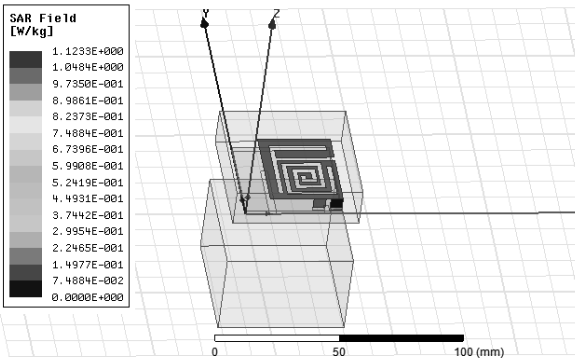

Figure 5: SAR value

The antenna has spiral slot along with the PIFA patch. This spiral slot is introduced to make the antenna resonate at multiband that is suitable for mobile application. PIFA with spiral slot and DGS are shown in Figure 5. The SAR value for this design is 1.10 watts/kilogram.

4. Conclusion

Two antennas are designed using HFSS software and the results were studied. The proposed antenna resonates at two bands namely UMTS and GSM 1800. Where GSM 1800 is the 2G mobile standard and UMTS is the standard for 3G mobile communication and the SAR is reduced by using PIFA. The SAR for this design is 1.10 Watts per kilogram which satisfies the FCC SAR rate for mobile phones.

5. Future Work

In future, we can modify the structure of the slot and make the antenna to resonate in multi band. Electromagnetic Bandgap Structure (EBG) can be inserted between the ground plane and the patch to further reduce the SAR.

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Authors Profile

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