Analysis of Mesh -Type Split Ring Resonator as Parasitic Radiator for Back Radiation Suppression in a Mobile Handset

Sarada Prasan Rout, Amlan Datta

***Abstract*—** As of late there has been tremendous advancement cellular technology, which has generated a hot spot in antenna design to create an improved antenna to be utilized in cellular systems. Antenna with minimum radiation towards the user's head is major task to accomplish. Our objective is to dam non-ionizing electromagnetic radiation emanating from handset and grant the antenna to radiate its energy in all other directions, while we attempt to uphold antenna performance at its peak. The performance of different specifications of the proposed antenna has been evaluated through simulations in free space as well as in the vicinity of the human head phantom model. The Specific Absorption Rate (SAR) is also computed for this antenna and the way antenna interacts with the human body has also been ascertained. All simulations are performed using the CST Microwave Studio. The results of elaborated antenna design with a Mesh-type parasitic radiator that have reduced radiation towards the user's head are conferred in this paper.

***Index Terms*—** Accomplish, Cellular Systems , CST, Mesh -Type Parasitic radiator, Non-ionizing electromagnetic radiation, Phantom Model, SAR

1 Introduction

The expanded utilization of mobile phones has been joined by expanding concern over the insurance of the human head from harmful electromagnetic radiation. Mobile handsets often placed close to or against the head while operating it during the call, which in turn puts the electromagnetic radiation in immediate contact with the tissues in the head, which may bring about an unfavourable health impacts at the appropriate time course. The effect of cellular radiation on the human body have been dealt in numerous ways [1]. Design of Antennas for handheld telephone receiver has generated increased keen interest within the cellular communications community. Radiation pattern of the antenna determines the extent that a user is exposed to electromagnetic fields is one of the reason for constant involment by the researchers to bring constructive changes in it. Voltage standing wave ratio (VSWR), radiation pattern and antenna gain of a handset are influenced by the user. The separating distance from an antenna in the handset and the head has a typical direct proportional relation between the specific absorption rate (SAR) along with antenna efficiency.

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The separating space between the mobile antenna and the user's head is said to be one of the important factors for deviation in antenna matching properties whether it is an external or built-in antenna set up. Popovi'c et al (2005) in comparing these results found that, "the handsets with built-in antenna configuration are much less sensitive to how the phone is held than the handsets with external antennas.
Moreover, he observed that the patch antenna produces the lowest SAR in the head tissues than monopole and helix antennas operated at 1.8 GHz" [5].

2 Methodology

The designing of the Antenna and its corresponding properties are simulated using CST Microwave Studio (CST). It is a specialized software tool that aids accurate and fast analysis of the 3D Electromagnetic simulations for high frequency elements such as antennas.

The applications of Planar Inverted-F Antenna in cell phones are increasing in a number of ways. There are a number of advantages for PIFA structures like having a simple design, multiband resonance properties, lightweight, low cost, attractive radiation pattern, reliable performance and having typical low SAR properties. As the integration of personal communication devices is progressing at a great speed, the necessity of the PIFAs like small, integrated antennas is also increasing at the same pace. SAR calculations have been studied with respect to the designed antenna. SAR is the measure of electromagnetic energy being absorbed by the biological tissue mass when exposed to radiating devices. This power absorbed by the user is measured by a parameter called SAR.

SAR = [1]

At this point SAR is in (W/kg). Also σ is the conductivity and ρ is the mass density, E_t is the total amplitude of electrical field in root mean square (V/m).

3 ANTENNA DESIGN

A fundamental PIFA structure includes a ground plane, radiating element at the top and the resonating top plate is being fed by a wire. The ground is being connected by a shorting plate and at one end of the top resonating patch.

3.1 Design Parameters

The setup of proposed antenna is composed by a main patch radiator at a height of 8mm from the ground plane of dimensions 45 mm x 30 mm. The metal chassis supports both the PWB and the Ground plane. A feed source is positioned on the ground plane and linked to the patch by a 2mm large conductor and a shoring plate of 3mm width is placed 6mm away from the feeding point. Figure 1 shows the geometry of the PIFA element optimized for operating at two different frequencies. In this structure the top radiating copper patch is of length 45 mm and the width is 30 mm. The patch thickness is 0.035 mm. Both the ground plane and the substrate plate are 0.9 mm thick. The substrate is of Rogers ultralam material.

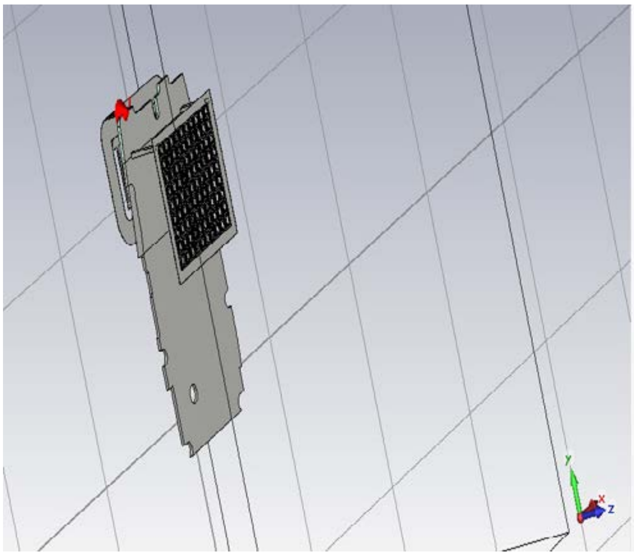

Fig. 1. Perspective view of PIFA Model

3.1.1 Meandered Patch

The top radiating patch is meandered to modify the antenna elements. This meandering operation allows to reach desired resonant frequencies and multiband operation. The meandering operation makes effective uniform flow of current throughout the length and radiation as well. The meandering operation is done to create slots in the upper radiating patch as a effective way for multiband operability of the handset antenna.

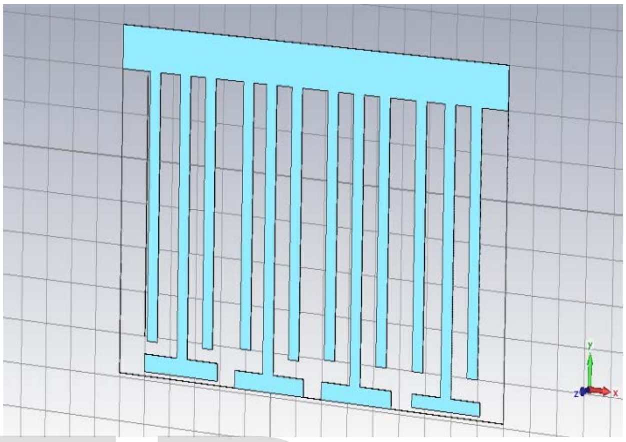

Fig. 2. Front view of PIFA Meander element Model

3.1.2 Corrugated RF Chokes

It creates an impedance mismatch that produces internal reflections from the top radiating patch. It is used for radiation at higher frequencies and restricts signal traces that cross over through the ground and get absorbed in the head. It is normally embedded in the ground plane.

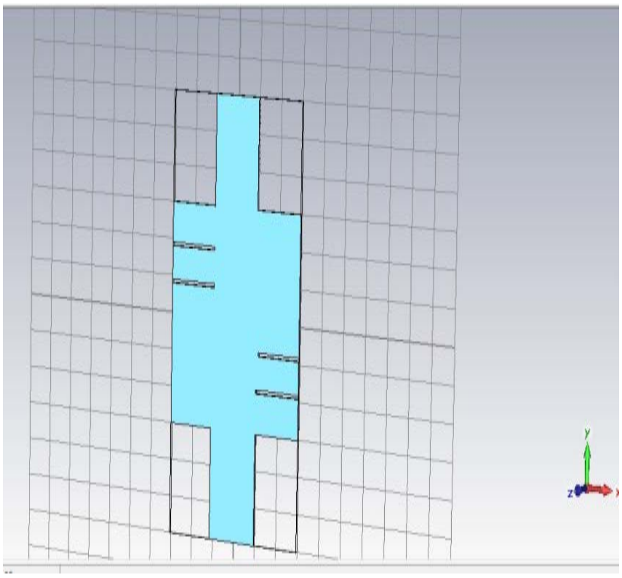

Fig. 3. Perspective view of RF Choke Model

3.1.3 Mesh-Type Parasitic Radiator

Parasitic radiator is a parallel plate like structure which is connected to the ground plane in the metallic chassis through the shorting strips of width 1.5 mm. Basic principle regarding the operation of parasitic radiator is said to be creating a sectoral null towards human head by cancelling a portion of the field near the human head. The currents being generated on the mesh type parasitic radiator are maximum and are in opposite phase to the currents on the printed wiring board, which results in cancellation of a major portion of radiation towards human head. An array of split ring resonator of size 1.9 x 1.9 mm and 2.9 x 2.9 mm for inner and outer cell, respectively. Silicon(lossy) is used as a major building material for mesh type parasitic radiator. The total electric field thus generated is increased towards human head but the parasitic radiator reduces the parallel field components to surface of the head, which in turn results in SAR reduction in the head.

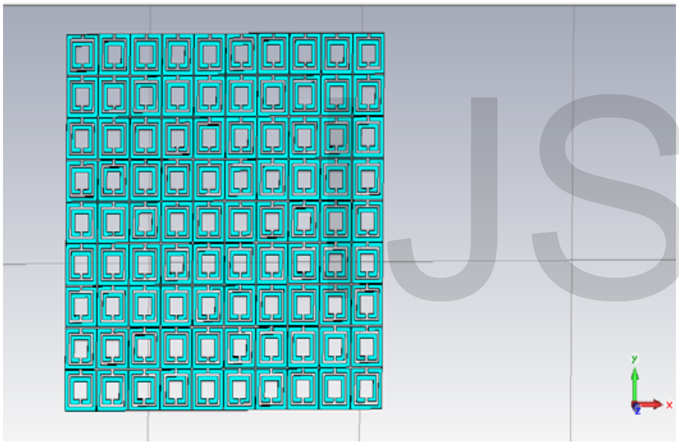

Fig. 4. Perspective view of Mesh-type parasitic radiator

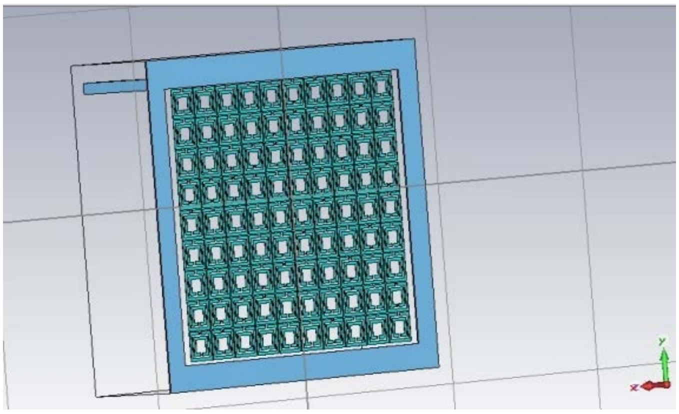

Fig. 5. Perspective view of Mesh-type parasitic radiator

Mesh-Type parasitic radiator is designed and aligned on the upper edge of the PWB in the metallic chassis. The parasitic radiator length is assorted in between 4 mm and 52 mm and the height from the metal chassis h is settled between 2.3 mm and 3.2 mm.

3.1.4 Generic Phone Model

In order to accurately characterize the operations and performance of the proposed antenna, a phone model is brought into context. The complete phone model consists circuit board, keypad, battery, plastic housing and LCD display. The conductivity and relative permittivity of the individual independent components taken for the whole setup were set to comply with the industrial standards. The materials used for simulating with their electrical properties are listed below in Table 1.

Table 1: Electrical properties of the materials for the generic phone Model

Phone Materials	Relative Permittivity ϵ_r	Conductivity σ (S/m)
Circuit Board	4.5	0.05
Plastic housing	2.4	0.005
LCD Display	3.0	0.02
Rubber	2.4	0.005

3.1.5 Head and Hand Model

The SAM Phantom head and hand model is used together with a simplified mobile phone as shown in the Figure 6.

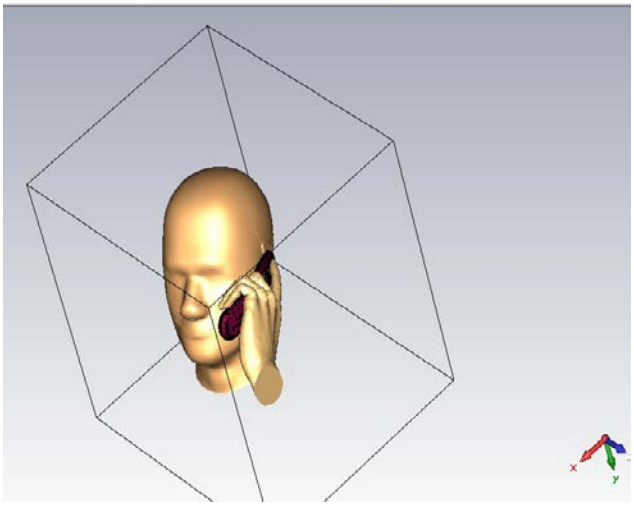

Fig. 6. SAM Phantom Head Model with Mobile Phone

SAM Phantom Head	Relative Permittivity ϵr	Conductivity σ (S/m)
Outer Shell	3.6	0.0016
Inner Tissue Simulant Liquid	42	1.44

Table 2: Electrical properties of the materials for the Phantom Head Model

Table 3: Electrical properties of the materials for the Phantom Hand Model

Hand Model	Relative Permittivity ϵr	Conductivity σ (S/m)
Tissue (Plastic shell)	20.36	23.98

4 ANTENNA SIMULATION RESULTS

4.1 Return Loss and Radiation Pattern

The return loss has been evaluated for the design through CST Microwave studio solver. The results shown in Figure 7 focus reasonable value of return loss. The minimum return loss is at 1 GHz and 1.9 GHz, the value is about -14 dB and -13 dB respectively.

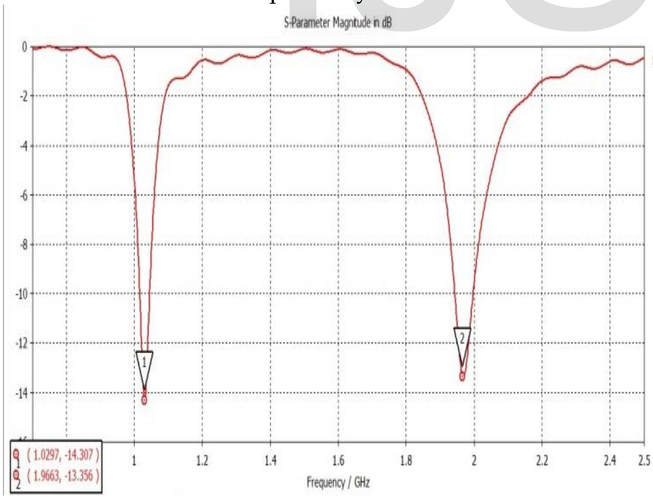

Fig. 7. Return loss(in dB)

The following Figure 8 shows the far-field radiation pattern of PIFA Antenna.

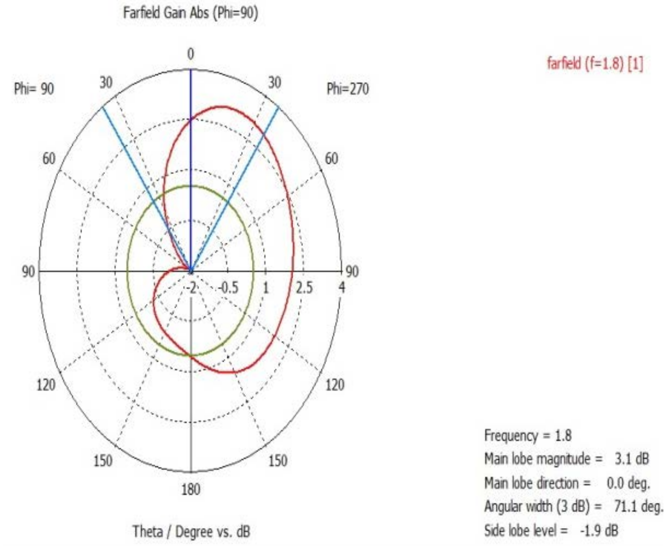

Fig. 8. Radiation Pattern

4.2 VSWR and Bandwidth Calculation

The graph of the Figure 9 shows the results of VSWR vs. Frequency. From which it can be seen that the VSWR value is found 1.5 as the expected value.

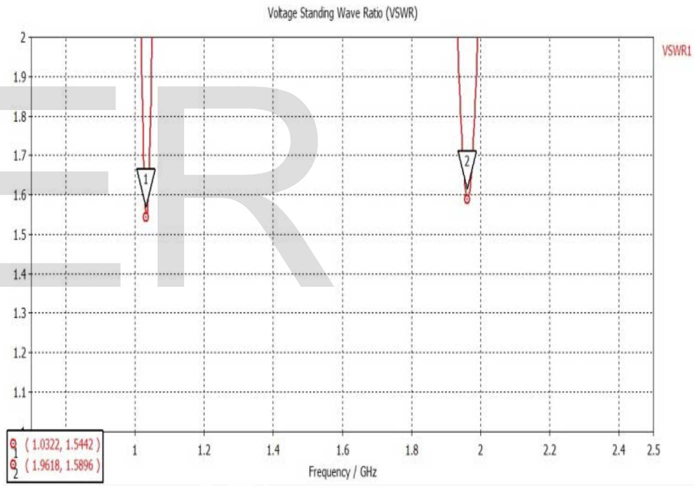

Fig. 9. VSWR of the PIFA antenna

4.3 Antenna Gain

The gain for the proposed antenna is found out to be 3.34 dB.

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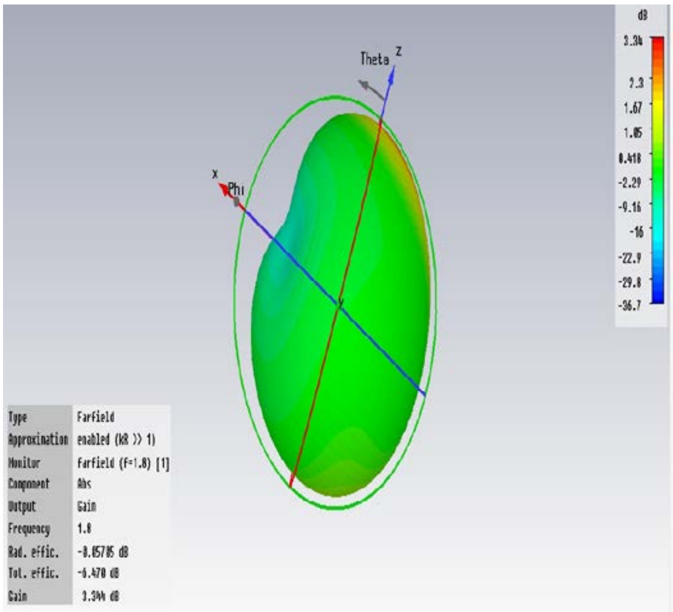
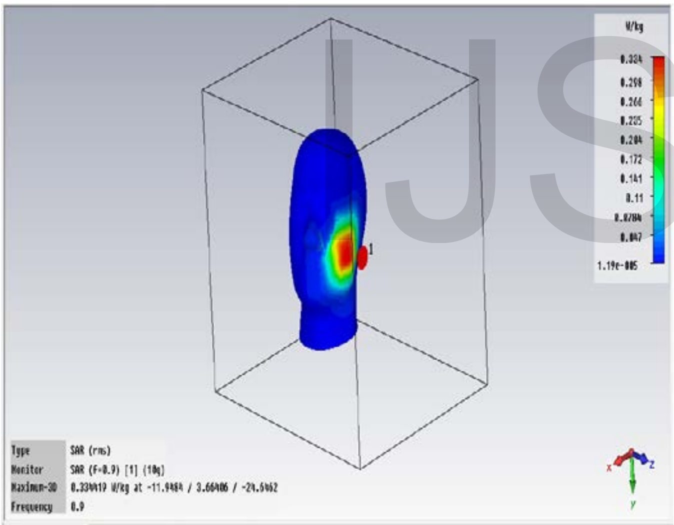


Fig. 10. Gain of the PIFA antenna

4.4 SAR Calculations

The PIFA antenna is embedded into the handset. The configuration is for measurement of SAR as shown in Figure 11.



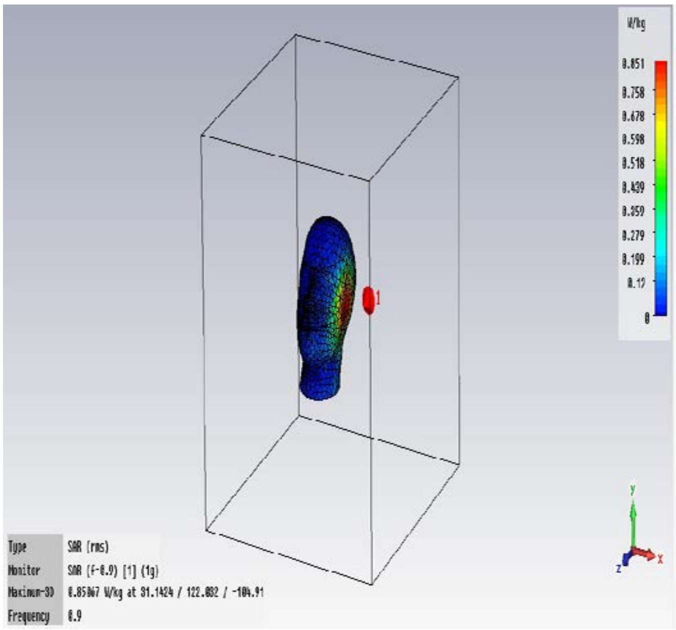


Fig. 11. SAR value (a) averaged over 10g of tissue (b) averaged over 1g of tissue.

For effective radiation in free space, it requires a good radiating structured antennas that are to be installed in the handset .Here in this case, the electric fields or the currents are being added in phase. The proposed antenna impedance is almost 50 Ohms. The FCC has fixed the value of SAR to sell a phone in the US which is about 1.6 W/kg averaged over 10g of tissue. In Figure 11(a), the SAR value is shown 0.33 W/kg averaged over 10g of tissue and in Figure 11(b), the SAR value is shown 0.85 W/kg averaged over 1g of tissue. These values are more preferable.

5 RESULT ANALYSIS

There are lots of PIFA antennas designed previously. The results of our proposed antenna are obtained from the transient solver of the CST MW Studio 2011. The transient solver shows the values of antenna gain, return loss, VSWR value, SAR value, radiation pattern. The return loss value obtained by the solver is very interesting. The return loss decreases as the antenna interacts with head model. The antenna gain is also appreciable. It can be analyzed that the antenna gain is also decreased as the antenna interacts with the head model. The value for VSWR is almost unity which has also a decreasing value as the antenna interacts with head. The SAR value has an acceptable rate of almost 0.33 W/kg averaged over 10g of tissue and almost 0.85 averaged over 1g of tissue. The SAR value can be reduced by following a technique of locating the antenna at the bottom edge of the Printed Circuit Board (PCB) [8]. The VSWR, return loss Numerical values can be shown in Table 4.

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Table 4: Numerical values of VSWR and Return Loss for the proposed Design

S/no	Parameters	Return Loss	VSWR	Operating Bandwidth
1.	Antenna (Free space)	-16	1.3	52 MHz
2.	Antenna (With Head Model)	-14	1.5	41 MHz

6 Conclusion

The proposed PIFA is designed in CST Microwave studio 2011 Software. The simulated results for the antenna designed can be used for cellular applications at 1 GHz and 1.9 GHz band. The interaction of PIFA with the human head model has a significant effect on antenna gain, VSWR and the radiation pattern. However, the simulation result of the proposed PIFA antenna gives a low value for peak SAR almost equal to 0.33 W/kg averaged over 10g of tissue and almost 0.85 W/kg averaged over 1g of tissue where the FCC guidelines to sell a phone in the US is 1.6 W/kg averaged over 10g of tissue. Electromagnetic radiation towards the user's head is dropped in the simulated antenna installed on the handset. It is also observed that the frequently used antennas can be replaced with the newly devised one, without any transformation in fundamental construction of cellular phone.

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