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Original Article

Design and Comparative Analysis of Amended PIFA with Multiple RF Absorber Materials for SAR Reduction

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Abstract *- Each mobile phone emits electromagnetic energy from the radio frequency, and the amount of that energy absorbed by the human head is measured by the specific absorption rate (SAR). There are standard limits, based on that cell phones should be below a certain amount of SAR. This paper designs and simulates a Planar Inverted F- Antenna (PIFA). The antenna is distributed from the grounded end to the intermediate point. The antenna configuration is more straightforward and lightweight, and the manufacturer can control the impedance matching without needing global matching parts. There is a requirement for an optimum shield material that can lower SAR while not jeopardizing the radiation structure's performance. The material is investigated and proposed as a good shield material for SAR reduction in this work. This unique implementation method achieved SAR values of 0.194 W/kg(Ferrite) and 0.176 W/kg(Foam absorber). The findings show that RF Absorbing Materials (Ferrite, Foam absorber) are excellent shielding materials for reducing SAR.*

Keywords *– Specific Absorption Rate(SAR), PIF Antenna, RF Absorber Materials.*

1. Introduction

SAR depends on the electric field distribution in the near-field region. The exposure limits are generally required over either 1 gram or 10 grams. It could result in tissue damage and hot patches in the human body [1], [2]. Ferrite sheet may typically decrease discontinuities for an antenna in the current distribution. Ferrites are the most common classes in ferromagnetic materials. Since the conductivity of the ferrites is weak, as electromagnetic waves are applied, less current is produced in the material. Using the above details about the SAR reduction process[3] [4], [5]. Due to the suppression of surface currents on the front of the mobile phone, the technique for SAR reduction by ferrite sheet connection was clarified. [6]. Specify protocols and procedures for calculating the peak spatial-average specific absorption rate (SAR) caused within a simplified user-head configuration of handheld devices (cell phones)[7]. The latest SAR limit clarified the ICNIRP recommendations compared to the previous limit. Several published papers investigated Human susceptibility to electromagnetic (EM) radiation, and the related health effects are a matter of public concern, undergoing ongoing scientific research.[10][11]. A defensive connection between the antenna and the human head was introduced in a ferrite layer[22]. A decrease of more than 13 percent was achieved over a 1 gm average for the spatial peak SAR. Research has been conducted on the impact of using ferrite sheets to suppress SAR, and it has been concluded that the shielding position has played a significant role in reducing effectiveness. An efficient method is locating the planar antenna at the back of the phone, away from the head. However, this poses extra design issues [13], [14]. Such an antenna configuration loses the quality of signals transmitted to the phone model from all directions. There were many issues with the existing design, such as high operating frequency, high radiation rate, durability, and high SAR value. This novel design presents the ferrite foam absorber sheet with Planar Inverted F-antenna for SAR reduction.

2. Literature Survey

Ahmed et al. [15] examined a Reject Band Filter (RBF) comprising eight-unit cell elements on the same side of a 1.5-mm thick FR-4 substratum. The efficiency of the unit cell is analytically and numerically assessed. Eventually, the field power is measured and observed to be diminished from 497.1 to 171 before and after installing the suggested array below the Wi-Fi antenna under a laptop computer. Yokota et al. [16] analyzed the modern environment, electromagnetic waves from different transmitting antennas, such as those that spread around the human body. Ali et al. [17]. This paper aims to design a new PIFA for low-SAR cell phone applications. The Time-domain solver considers the hexahedral mesh used in this simulation with an adaptive meshing scheme. The simulation and the results of the investigation are roughly the same. Bhargava et al. [19] However, how biological tissues respond to the radiation overload limit from mobile phones is still unclear. This study aims to determine how excessive mobile phone radiation exposure affects the temperature increase and specific absorption rate (SAR) in heterogeneous head models. It is commonly investigated how SAR and temperature distributions in different types of cranial tissues are affected by three main patterns of use calling, video calling, and texting. Considering the safety recommendations, the study's findings point to a significant influence of mobile phone radiation on voice calling. However, according to the investigation, a child's head absorbs more mobile phone radiation than an adult's.

K Rajeev et al. [20], in the virtual homogeneous human muscle phantom model, the researched specific absorption rate (SAR) field of the planer inverted F antenna (PIFA) is investigated. Two antennas are designed to resonate at 2.4 GHz. The new design measures 25 to 22, 4 mm in size, and is mounted on a 20 mil substratum and at 1 mm from the antenna plane. It is 2.1 W/kg. The design's gain inside conducting lossy tissue is quite good, at -21.57 dB and -22.3 db. The antenna provides high radiation efficiency of approximately 90 percent for 900 & 1800 MHZ. The SAR analysis of the suggested antenna shows that radiation is high. The design of the SAR Reduction Technique for Attaching Ferrite Sheet and Foam Sheet Analysis for SAR Reduction in the Human Head are discussed in this novel work.

3. Amended Planar Inverted F- Antenna (PIFA) with Multiple RF Absorbers

Antennas are a connection in a communication system between the transmitter and the free space or the free space and the receiver. As communication devices become smaller, the antenna becomes an essential part. New trends in antenna design focus primarily on antenna compactness, robustness, and compatibility with existing RF circuit components.

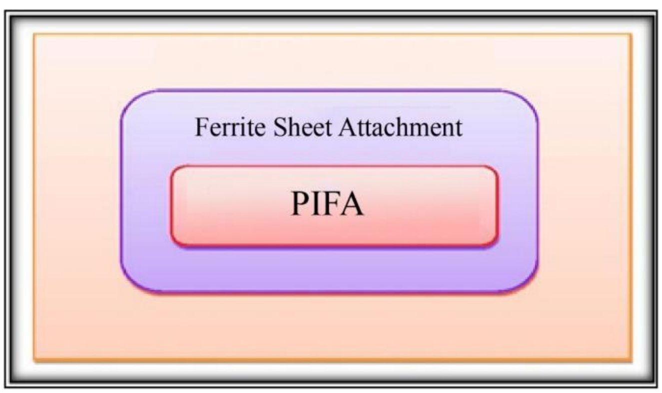


Fig. 1 Amended planar inverted F-Antenna (PIFA) with ferrite sheet for sar reduction

Everybody uses mobile phones that use E.M. waves to penetrate human tissue in today's world. Human absorption of these E.M. waves impairs human tissues. Therefore, concerns regarding safety aspects and the dangerous effects of E.M. waves are required. Existing work faces many problems, such as high radiation patterns and increased operating frequency. Specific Absorption Rate is high and more expensive. SAR is also a crucial parameter in antenna design. The antenna is fed a distance from the grounded end from an intermediate point, the antenna design is short, and the designer can control the matching impedance without foreign matching components inside the Antenna Design Ferrite sheet attachment for SAR reduction. Using the Ferrite Sheet Attachment in the antenna achieves High reliability and reduces the Specific Absorption Rate. It operates at low operating frequencies. After this antenna design, the Evaluation of SAR is simulated in the 3D radiation pattern of the antenna with the Ferrite sheet and foam absorber sheet; the distance between the phone and the Ferrite Sheet and foam absorber is 10mm. The head model is simulated using the HFSS, and this methodology gives some efficient parameters results and improves the SAR Reduction.

3.1. Planar Inverted F-Antenna (PIFA)

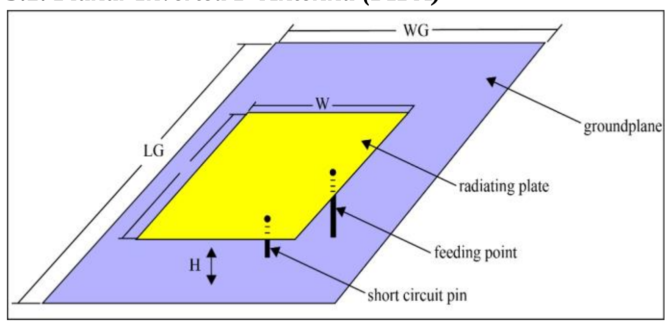


Fig. 2 PIFA antenna with shorting circuit strip

The standard PIFA configuration is shown in Figure 2. A feed wire feeds the antenna at the base to connect the cable to the ground plane. The PIFA is an elegant wireless network antenna where wireless systems have minimal antenna capacity. Including a short circuit strip makes it possible to accurately measure input impedance with a top plate with a value of less than /4.

A semi-rigid coaxial with a centre conductor extending past the end of the outer conductor makes up the PIFA feed wire. A small hole is drilled in the ground plane at the indicated location, and the coaxial outer conductor is soldered to the hole's edge. The PIFA-type standard short circuit plate is an excellent method. To reduce antenna capacity, but results in low bandwidth impedance.

The resonant frequency of PIFA is:

$$L1 + L2 = \lambda/4 \quad (1)$$

$$W/L1=1, L1 + H = \lambda/4 \quad (2)$$

$$W=0, L1 + L2 + H = \lambda/4 \quad (3)$$

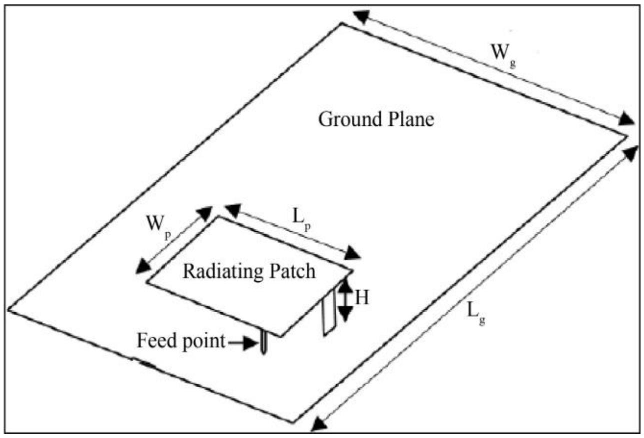


Fig. 3 The structure of PIFA

L1, L2 is the Length of PIFA, and W is the Width of PIFA. It is, therefore, appropriate for medical applications. This spacing between the feed and short pins enables impedance matching. The shorting pin and single feed are inside the slot for efficient impedance matching. This antenna's radiation pattern is a function of space location with relative radiated power. Between the open end and the short end, the feed is located. The location of the feed controls the impedance of the input. In PIFA, as shown in Fig.4, a plate forms the shorting pin. Here the length is L1, and the width is L2. The resonant frequency varies based on W. When W= L2, the whole patch width is the same as the short stick.

3.2. Ferrite & Foam absorber Sheet Attachment

The SAR quality improves when an RF-absorbing material is placed in front of an antenna and a person's head. 2.6 GHz was used for SAR antenna reduction studies. The FDTD technique uses different locations, sizes, ferrite sheet materials and Foam Materials. A thorough Three Locations human head model and FDTD technique are also used. Dispersive models for all dielectrics are used in the simulation to represent the ferrite layer& Foam Sheet precisely. The Ferrite Sheet Foam is attached. Sheet 1 has dimensions 90mm*1.5mm*0.2mm, Sheet 2 Dimensions are identical to Sheet 1, Third sheet is attached with different dimensions 90mm*45mm*0.2mm for better Reduction of Sarthe ferrite sheet is attached with the PIFA above the sub strum.

The ferrite sheet is printed with a permittivity of 12 and relative permeability of 1000. The SAR's reduction efficiency depends on its height and width. Increasing the width of the ferrite surface between the phone models and the head model decreases the SAR value at a maximum of 20 mm. According to the results, just reducing the cumulative current on the conductive box's front significantly raises the spatial limit of SAR. This is because the reduced power consumption in the brain is substantially more than the power dissipated in the ferrite plate.

4. Results and Discussion

The proposed methodology is used in ANSYS HFSS, and the simulation results are below. The proposed technique is discussed in Section 3 before, and in this Section, its performance is examined in detail. The following system specification implements the suggested method in ANSYS HFSS's working platform.

4.1. Simulation Outputs

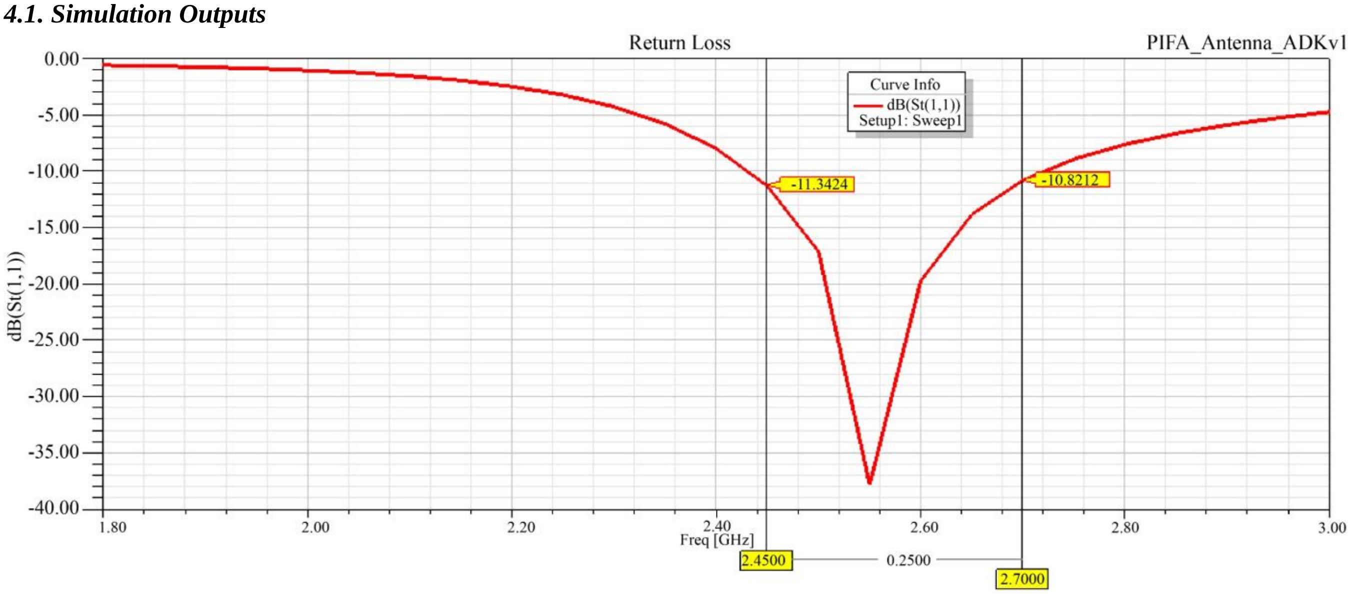


Fig. 4(a) Return loss @ 2.6GHz(Foam absorber)

The ferrite sheet & foam sheet with amended PIFA for SAR reduction simulation outputs are shown below. Also, the simulated representation of each parameter in the simulation has been deliberated.

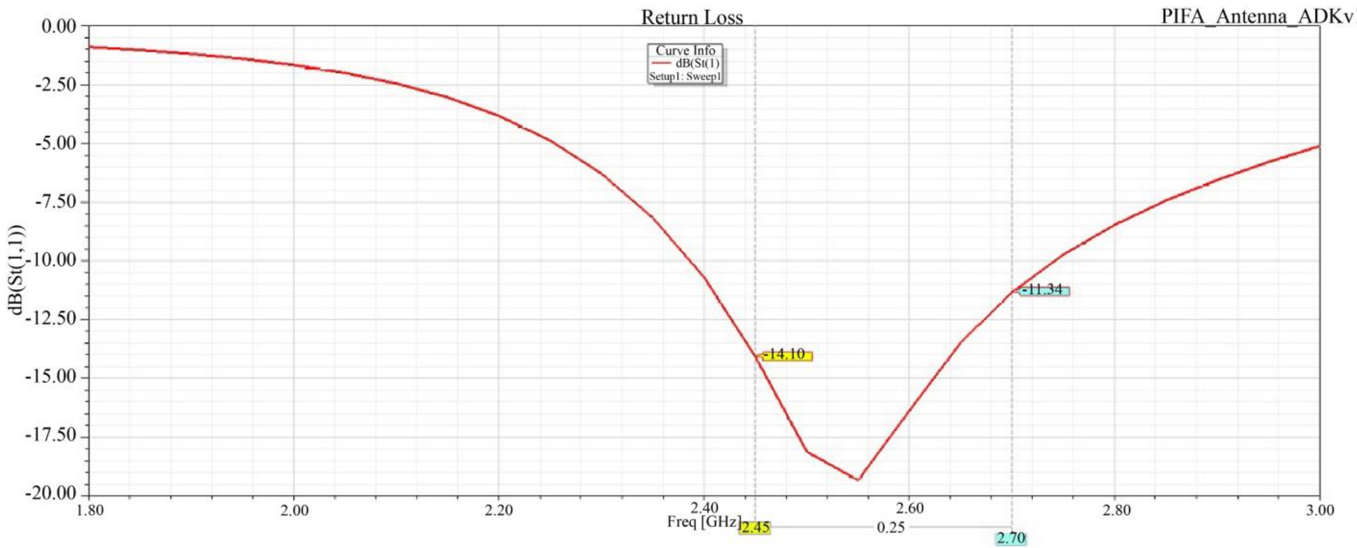


Fig. 4(b) Return loss @ 2.6GHz (Ferrite sheet)

Figure 4 (a),(b) states return loss of planar inverted F-Antenna of our proposed ferrite sheet and foam sheet attachment with Amended PIFA for SAR reduction.

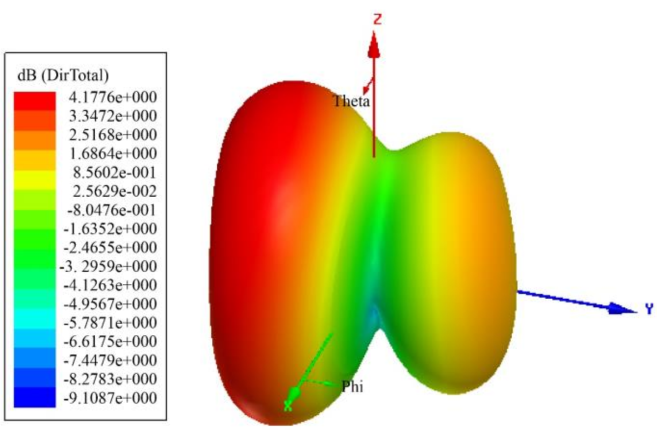
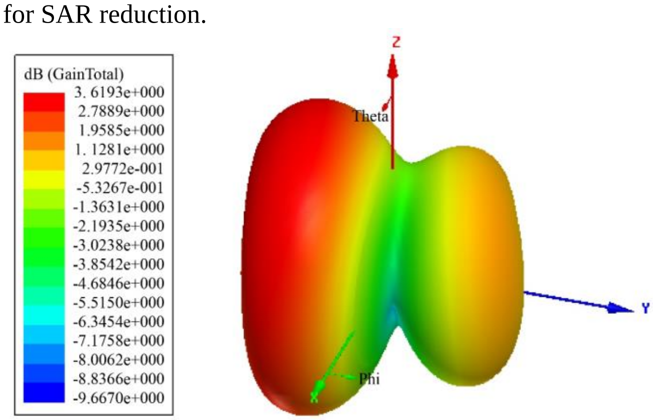


Fig. 5 Directivity of PIFA antenna

Fig. 5 States the directivity of planar inverted F-Antenna of our proposed ferrite sheet attachment with amended PIFA for SAR reduction.



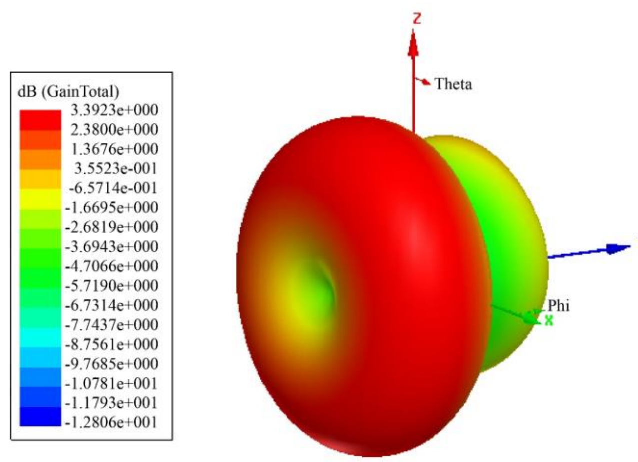
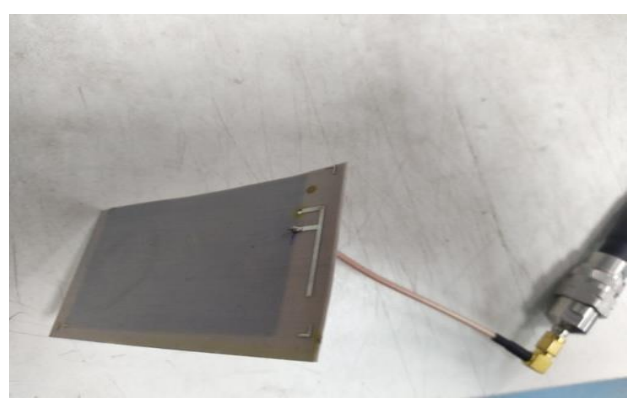


Fig. 6(a) Gain of PIFA antenna (Ferrite sheet), (b) Gain of PIFA antenna (Foam sheet)

Fig. 6 shows the states gain of the planar inverted F-antenna of our proposed ferrite sheet attachment with amended PIFA for SAR reduction.



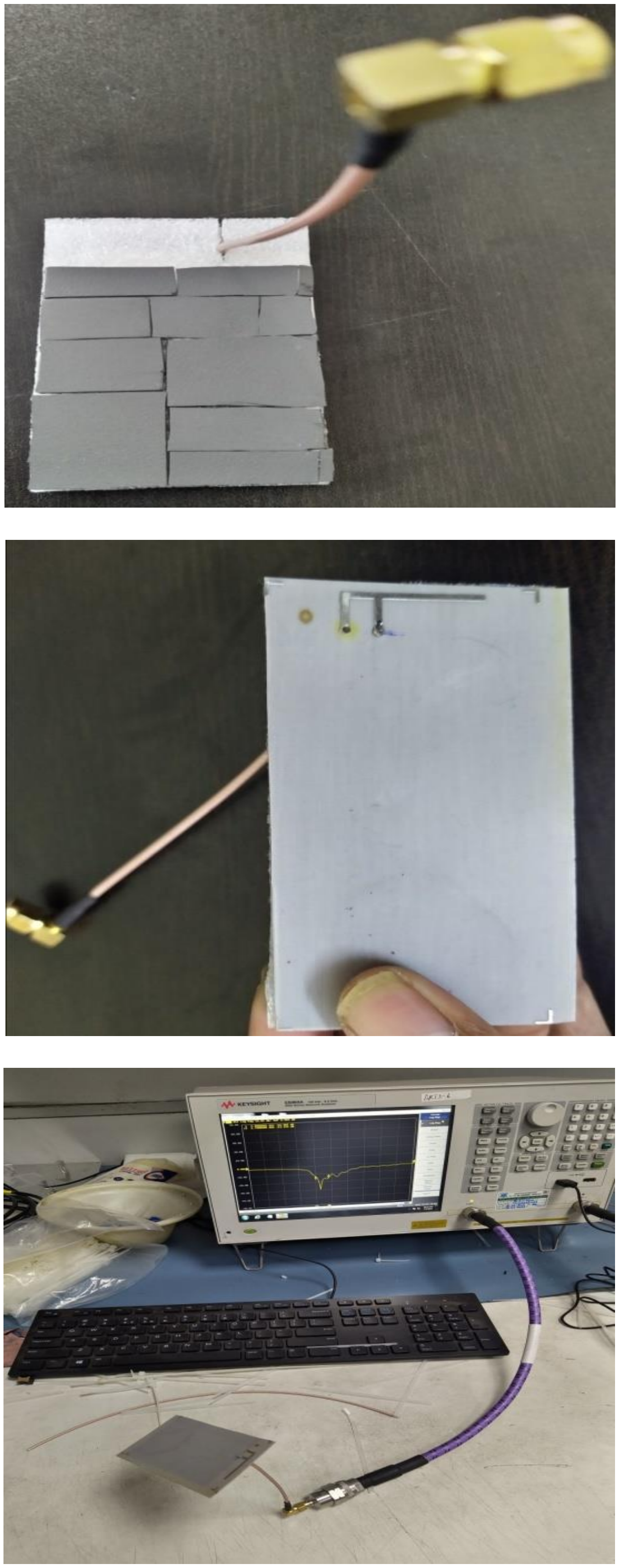


Fig. 7 PIFA antenna design top view

Fig. 7 illustrates the states design of planar inverted F-Antenna of our proposed Ferrite and foam sheet attachment with Amended PIFA for SAR Reduction.

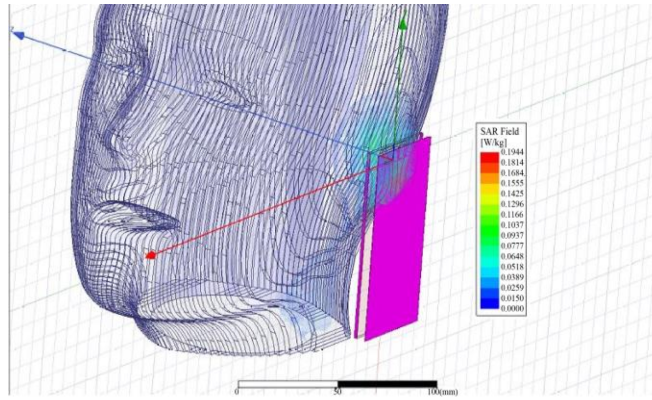


Fig. 8(a) SAR reduction of PIFA antenna using ferrite sheet

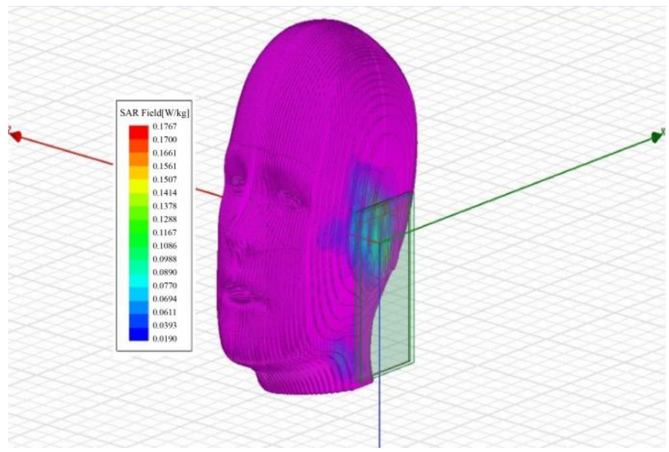


Fig. 8(b) SAR reduction of PIFA antenna using RF absorber (Foam sheet)

Fig. 8(a),(b) States SAR reduction of planar inverted F-antenna of our proposed ferrite sheet and foam sheet attachment with amended PIFA for SAR reduction.

4.2. Comparison Stratagems

To evaluate the overall comparison of the proposed PIFA antenna with ferrite sheet attachment and foam absorber sheet attachment are as follows:

Table 1. Comparison of PIFA antenna with ferrite sheet attachment and foam sheet attachment

Parameter	With Ferrite Sheet	With Foam Absorber Material(Foam Sheet)
Return Loss	-19.55	-38.1
Gain(dB)	3.3	3.61
Bandwidth(GHz)	0.250	0.250
SAR(W/Kg)	0.194	0.176

Table 1. States comparing ferrite sheet & foam absorber sheet attachment for planar inverted F-antenna for SAR reduction against return Loss, bandwidth, and gain.

5. Conclusion

RF shields are made from a variety of absorbing materials. Ferrite and Foam absorber sheets are preferred as absorbers in this paper since they are less weight and do not degrade the modified Planar Inverted F-Antenna (PIFA) radiation pattern. The antenna is fed from the midpoint at a distance from the grounded end. The antenna design is shorter and more compact, and the designer can control the matching impedance without international matching components. The Evaluation of the header model is simulated using the ANSYS HFSS, and this organization results in with and without ferrite sheet Attachment based on Specific Absorption Rates are 0.291W/kg and 0.194 W/kg. SAR Values obtained by Placing Foam absorber sheet attachment is 0.176 W/kg.

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