A WIFI Antenna Radiation Effects on Human Head in the ISM Band

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***Abstract*—This article describes in the first, the design of a new microstrip patch antenna for WIFI/WLAN applications (IEEE 802.11 b/g/n). Secondly, the article presents the effect of electromagnetic waves on a model of the human head exposed to the antenna designed in the ISM2450 band. By adopting a model tissue to seven layers of an adult. The objective is to evaluate the specific absorption rate (SAR) due to the propagation of electromagnetic waves along a human head for different antenna-head distances in simulation anatomic based model of the human head at a frequency of 2450MHz.**

All results, reflection coefficient, VSWR, radiation pattern, SAR and field distributions are presented. The simulation analysis was performed using the HFSS software.

***Index Terms*—WIFI/WLAN, microstrip patch, SAR, human head, HFSS.**

I INTRODUCTION

The recent advances in wireless communication systems, such as wireless local area networks (WLAN), wireless local loop (WLL), Broadband systems 3G etc, have induced a great interest in microstrip antennas. These have grown tremendously in recent years due to their ability to respond to the particular constraints of size, weight and especially cost imposed by the emerging mobile systems [1]. Future wireless systems will provide various services including the technology develops very quickly. A wireless communication technology has been an important topic for the telecommunication system because of its low cost and high opportunity. These systems specify the frequency range of 2.4 GHz to 2.5 GHz, which operate in the ISM band [2].The ISM (Industrial, Scientific and Medical) bands are frequencies that can be used for domestic or industrial scientists like medical applications, with the exception of radio applications, without requesting permission from the authorities. Frequency bands and possible limits emission levels are defined by the FCC Part 18 . The ISM frequency bands [3] assigned for multiple-user applications are suitable for, and expected for, the wireless LAN applications. The applications typically support a limited number of users in an indoor area. Thus the users are unconsciously exposed to EM waves which directly come from antennas or which are reflected and scattered from objects existing in the area [4]. The applications in these frequency bands also include portable telephones, microwave ovens, and so forth.

This development raises questions safety of new technologies. There has been an increasing public concern about possible health hazards due to exposure to EM waves. Accordingly, many international protection organizations and regulatory agencies have proposed the safety standards for exposure to EM waves [5–6]. These standards are based on the SAR, which is a measure of the EM power absorbed in the tissue. The advantages of analyzing specific absorption rate generated by cellular phones inside a human head are among others [7], as follows; verification of the compliance of phones with standards, electromagnetic solver, experimentally validated, gives not only reliable values of specific absorption rate but also locations inside a head [8], high resolution in field evaluation could be of interest, as input data for the analysis of athermal effects. Several methods have been used to study the effect of an antenna radiator on a human head such as homogenous or multilayered concentric spheres, multilayered planar model [9].

In this work, we propose to study and design a new microstrip patch antenna operating in the ISM band with a resonant frequency of 2450MHz. We will proceed by following an evaluation of specific absorption rate in the human head in a heterogeneous spherical model consists of seven layers for antenna designed. Thus, the effects of operating frequency (2450MHz) and gap distances between the antenna and the human head on distributions of SAR within the human head are systematically investigated.

II ANTENNA GEOMETRY

Figure 2 illustrates the top, bottom and side views of the geometry of the antenna studied. The antenna is simulated on an FR4_epoxy substrate of 60 ×70 mm^2 with a dielectric constant ε_r=4.4. The thickness of the substrate is H=1.58 mm. A rectangular patch including technical slots with different dimensions shown in Table

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1. The antenna is fed by a microstrip line in order to increase the bandwidth and gain.

TABLE 1:
SPECIFICATIONS OF THE PROPOSED ANTENNA

ELEMENTS	DIMENSIONS
Patch	**W_p=28.2mm ; L_p= 36.7mm**
Microstrip line	**W_{Ml}=1mm ; L_{Ml}=25mm**
Ground plane	**W_G=18mm ; L_G=60mm**

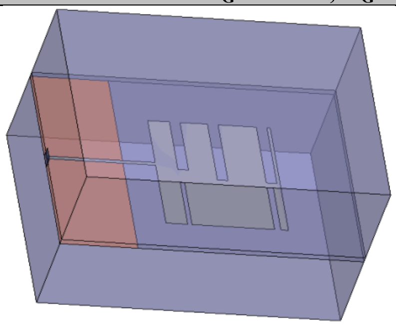
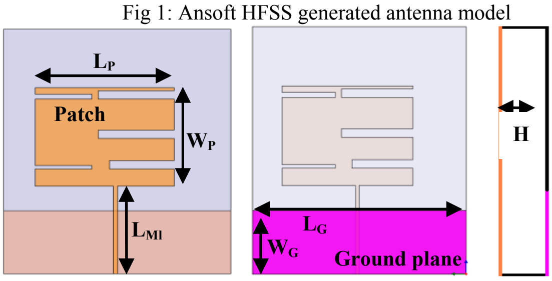


Fig 1: Ansoft HFSS generated antenna model



(a) (b) (c)

Fig 2: Geometry of the proposed antenna. (a) Top view, (b) Bottom view, (c) Side view

III RESULTS AND DISCUSSION

Figure 3 shows the different values of the reflection coefficient obtained.

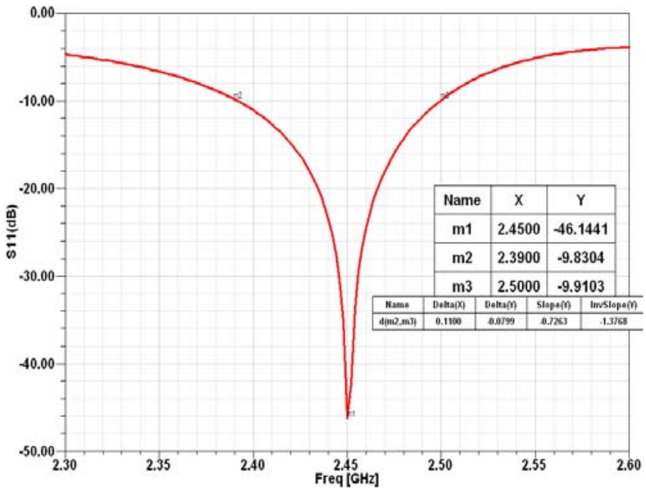


Fig 3: Reflection coefficient of the proposed antenna

It was found that the antenna resonates in the desired frequency band as shown in Figure 3. Indeed, for $|S_{11}|$ <-10 dB: band ranges from 2.39 to 2.5GHz with a resonant frequency 2.45GHz. The bandwidth is 110MHz (4.49%) which is used for WLAN applications namely the ISM band used by BLUETOOTH (2.4GHz-2.485GHz) and wireless systems (2.4GHz for 802.11b and 802.11g). Also, the band is sufficient for the intended width by the IEEE specifications which is 83.5MHz.

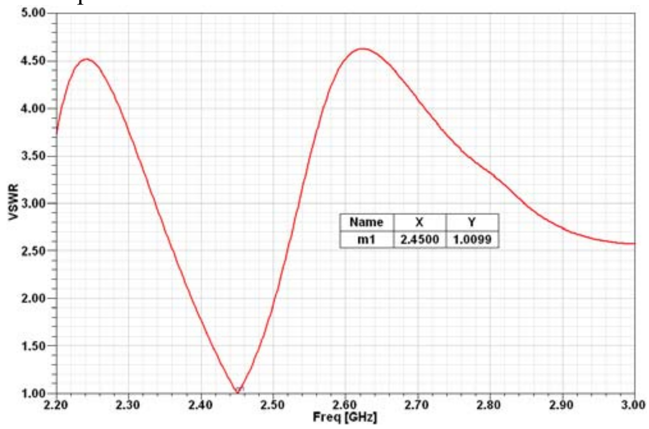
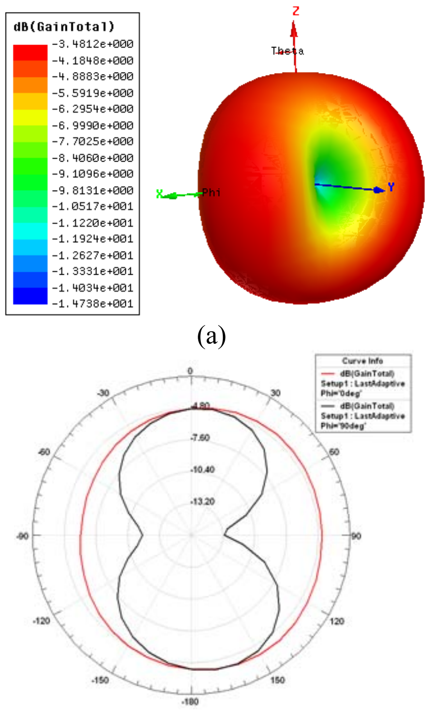


Fig 4: The VSWR of studied antenna

The variation of VSWR with frequency shows that it is less than 2dB for the resonance frequency which is 2.45GHz, as illustrated in Figure 4. A bandwidth equal to 110 MHz which is 4.49% from the center frequency. According to IEEE specifications, the width of the WLAN band represents 3.4% around 2.45 GHz. Our case is sufficient for this bandwidth and allows us to cover the ISM band.



(a)

(b)

Fig 5: (a) 3D-Gain Total, (b) 2D Radiation Pattern

The radiation pattern of the antenna characterizes the variation of the radiated power over long distances in different directions in space. The radiation patterns of the antenna studied are shown in Figure 5. They are almost omnidirectional allowing use of this antenna for applications in the ISM2450 band and specifically for WIFI.

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IV DOSIMETRY

4.1 Methods and Model

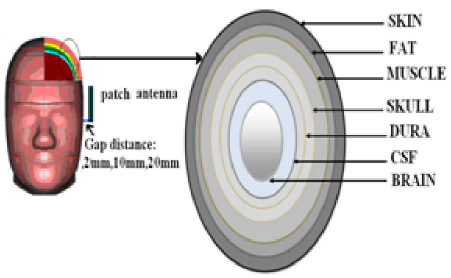
When electromagnetic waves propagate through the human tissues, the energy of electromagnetic waves is absorbed by the tissues. Interaction of electromagnetic fields with biological tissues can be defined in term of specific absorption rate (SAR). The specific absorption rate (SAR) is an index that measures the level of radio frequency electromagnetic field in the human head, as emitted by the mobile phone when operating at full power, in the worst conditions. Its unit is watts per kilogram (W/kg). Governments have put standards for the maximum SAR that should not be exceeded to avoid health hazards. This maximum is set to 1.6W/kg averaged over 1g of tissue, or 2W/kg averaged over 10g of tissue, in USA and Europe [10], respectively. The specific absorption rate is described by the following equation:

$$\mathbf{DAS} = \frac{1}{2} \cdot \frac{\sigma}{\rho} |\mathbf{E}|^2 \qquad (1)$$

Where σ is electric conductivity (S/m) and ρ is the tissue density (kg/m^3). SAR is calculated as a function of position from the estimates of local fields and tissues properties.

In this study, we will evaluate the effects induced by the WIFI antenna located on human head side with different distances are considered as a source of radiating near field for the model of the human head

The figure 6 (a) shows the spherical model of the human head and the antenna position. This model consists of seven layers, as is shown in figure 6 (b), which are the skin, fat, muscle, skull, dura, CSF (cerebrospinal fluid) and brain. The dimensions we have chosen are as follows: for the sphere, we took a radius of 90 mm, skin thickness 2mm, fat 1 mm, 4 mm for muscle, skull 10mm, 1mm Dura, 2mm CSF and the last layer is the brain.



(a) **(b)**

Fig 6: The Model of a human head. (a) Cross section human head model with patch antenna. (b) Model composed of seven layers.

The propagation depends on the dielectric properties of the layer, density and wavelength. Table 2 gives the values of these properties for the 2450MHz frequency [11].

TABLE 2:
THE PROPERTIES OF THE MATERIALS USED IN THE SIMULATIONS AT 2450MHZ

Type of tissue	2450MHz		
	ε_r	σ (S/m)	ρ (kg/m^3)
SKIN	42.85	1.59	1100
FAT	10.82	0.26	1100
MUSCLE	53.64	1.77	1040
SKULL	15.01	0.57	1850
DURA	42.03	1.66	1030
CSF	66.24	3.45	1030
BRAIN	42.61	1.48	1030

4.2 Specific Absorption Rate

The figure 7 shows the results obtained from the flow of local and average specific absorption on the spherical seven layer model with three different distances between the human head and antenna 2mm, 10 mm and 20 mm at 2450 MHz and a power of 100mW.

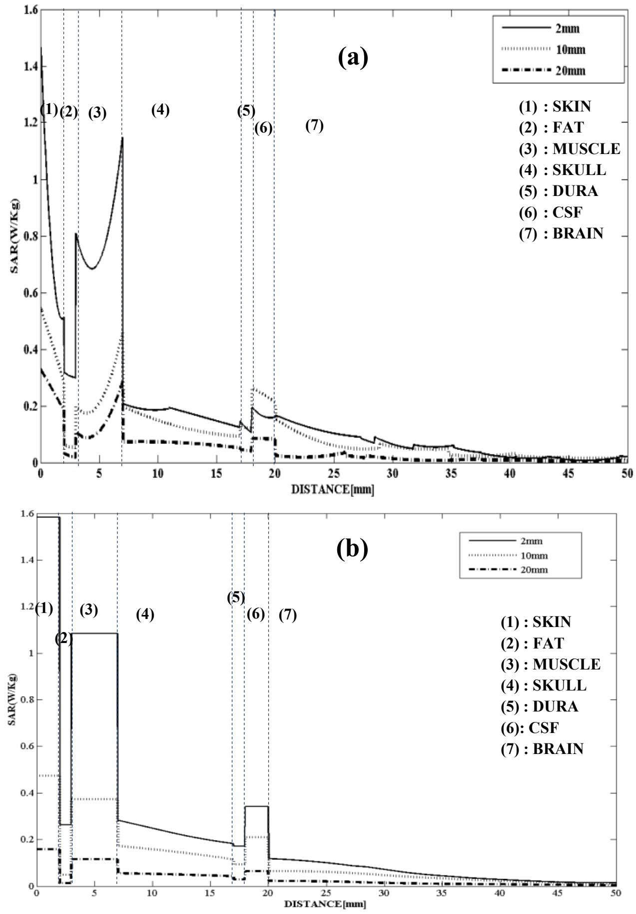


Fig 7: SAR variation at different distances WIFI antenna-head. (a)Local SAR, (b)Average SAR

The results allowed us to conclude that more than the antenna is closer to the human head, more than the SAR reached high values and vice versa. Thus, from Figure 7 the penetration of specific absorption rate in tissues and for different distances does not exceed the standards set by IEEE and FCC namely 1.6W/kg.

At layers, we note that the SAR has three peaks respectively located in the skin, muscle and CSF, which is mainly due to their relatively high dielectric properties. This allows us to say that these layers protect the brain because it absorbs a small radiation.

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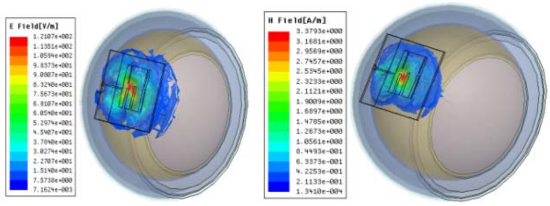

Fig 8-a: E_field and H_field at 2mm

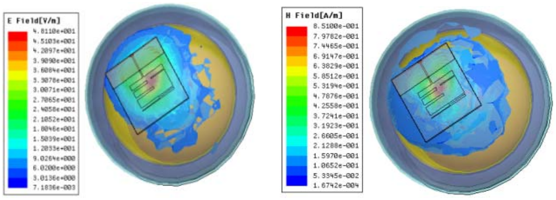

Fig 8-b: E_field and H_field at 10mm

Figure 8 shows the distribution of the fields E and H of the head model to seven layers with an antenna head distance of the order of 2 and 10mm. Note that the field is decreasing with distance and that these values are very important in the nearest antenna tissues.

V Conclusion

In this work we present in the first part a novel design of a miniature microstrip patch antenna. Light weight, low-cost, plain configuration are the advantages of this structure. Bandwidth enhancement has been improved by suitably cutting slots into rectangular patch which allowed us to cover ISM2450 band. The second area includes a study of the effects of electromagnetic waves on a model of the human head exposed to antenna for the wireless frequency at 2450MHz. This study shows that our patch antenna meets the standards when placed at various distances antenna-model human head at an incident power of 100mW. The numerical simulations shows several important features of the energy absorption in the human head and demonstrate that our patch antenna exhibits good electrical performance and thus can be considered as a suitable candidate for various applications in ISM-band (IEEE 802.11 b / g / n).

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