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Design of New Antenna in the Form of Dollar-Symbole for WLAN Technology

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Abstract

Nowadays, several interesting patch antenna structure is proposed. In this paper, we are proposing a new rectangular structure in the form of a dollar-symbole, fed by a microstrip line is made with FR4 substrate, a thickness of 1.6mm, and a relative permittivity of 4.4. The ground plane on the antenna is printed, while contain two slots. The resulting antenna has been found to possess a compact size of 30 mm × 30 mm, and suitable for wireless local area network (WLAN). Two resonant frequencies are obtained by the proposed antenna. The low-band resonant frequency is located at about 2.4GHz, with -10 dB impedance bandwidth from about 1.9 GHz to 3 GH, and the high-band resonant frequency is located at about 8.8 GHz, with -10 dB impedance bandwidth from about 7.6 GHz to 10 GHz.

In the first part, a comparison study of a patch antenna with slots and without slots is proposed; in the second part, the study of antenna parameters which affect dimensions is presented.

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Keywords: Patch antenna; WLAN; Bandwidth; miniaturization; Slots.

1. Introduction

Lately, the increasing number of communication standards (GSM 900, GSM 1800, UMTS, WLAN, Bluetooth, ...) which gives the opportunity to design multi-band [1-2] or broadband antenna. Currently, several techniques [3-4]

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are used to reduce the size of the antenna that gets multi-band antennas and broadband. To resonate at several frequencies, the techniques used an antenna are very diverse and based on several concepts and then many techniques for obtaining multi-band antennas. The use of a slot allows the down sampling and the control of the higher modes. In addition, the slots in the radiating element cause a change in current distribution level. Therefore, a change in the impedance of input and the current path. This approach is used to design of a dual band antenna that we will present [5-6].

Many authors have presented antenna designs [7-9] suitable for WLAN operates in 2.4 GHz band and also in (5–6 GHz) [10-11]. In fact, the printed antenna is one of the best antenna structures, because of its low cost and design compact [12-13]. Much work has been made in recent years to develop this type of antennas [14-15]. We studied a new antenna approach to improve the effectiveness of radiation and the performance of antennas with a miniaturization of the size and the effect of slots on the ground plane. Indeed, we studied the performance of antenna dual band consisting of an element of radiation in the form of a dollar-symbole. The study was carried out for the band of 2 to 3 GHz 7.8 to 10 GHz. The geometry of the antennas and the results were obtained using HFSS simulation software.

Nomenclature

L	length of antenna
L1	first slot position (parameter)
L2	distance of the first slot from the microstrip line
W	width of antenna
CRMPA	Conventional Rectangular Microstrip Patch Antenna
WLAN	Wireless Local Area Network

2. Antenna configuration and design

The Basic antenna (without slots) is in the form of a dollar-symbole printed on substrate FR4 (height h = 1.6 mm, a relative permittivity of 4.4). The antenna is powered by a 50 ohm microstrip, Lf = 12.5 mm and the length width Wf = 3 mm, the antenna is mounted on a partial size ground plane (30 * 10.3) mm as it is shown in figure 1. In order to get an antenna dual band, we involved two slots in a symmetrical manner on the partial ground plan as shown in figure 2 and proceed to a parametric study of the antenna:

Table 1. Design specification of the proposed antenna

Parameters	Value (mm)
L	30
Lf	29.7
Lg	10.3
W	30
Wf	3
a	3
b	15
c	3
X	8
Y	3

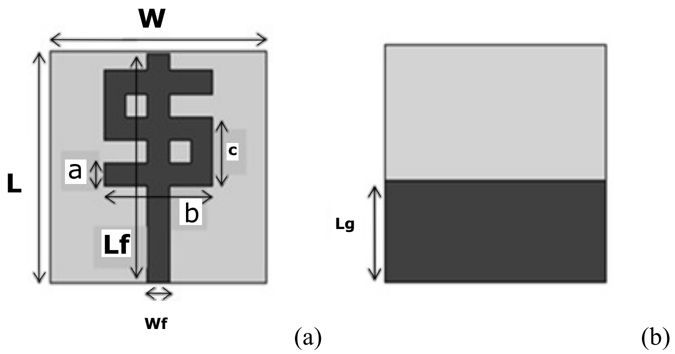


Fig. 1. First structure without slots (Basic antenna)

The configuration of antenna:

Figure 1.a which describes the structure of antenna from the top; figure 1.b which is the down view of antenna without slots.

Figure 2 illustrates the configuration of the proposed antenna. (fig2.a) is the top view and similar to the basic antenna, in the (fig 2.b) shows the down view with two slots, those are symmetrical.

The structure of the proposed antenna is simulated using finite element method (FEM) software, HFSS and CST Microwave Studio.

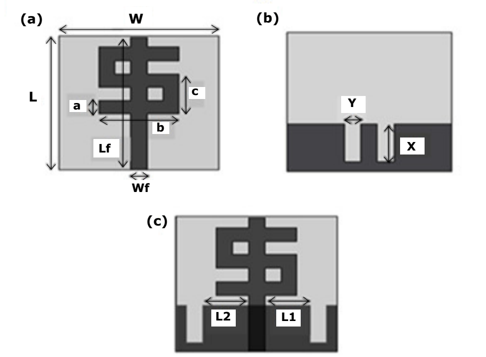


Fig. 2. The geometry of the proposed antenna with two slots

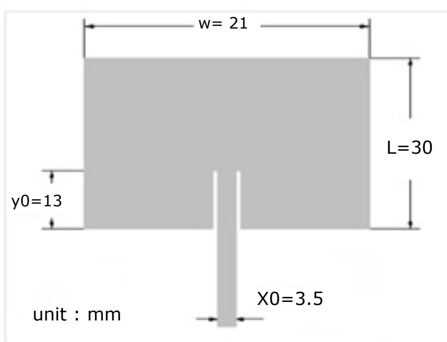


Fig. 3. Geometry of CRMPA antenna (Reference antenna)

During this study, the new antenna configuration will be compared with an antenna widely used in the LAN application systems. As shown in the figure 3, it illustrates the configuration of the reference antenna CRMPA (Conventional Rectangular Microstrip Patch Antenna).

3. Simulation and study results

The configuration of the proposed microstrip transmission line-fed monopole antenna with partial ground plane is illustrated in Fig. 2. The antenna is fed with a 50 Ω microstrip line and fabricated on the FR4 substrate with thickness 1.6 mm and relative permittivity of 4.4. The radiating element is in the form of a dollar-symbole.

The reflection coefficient (1) expresses the ratio of reflected power to incident power at port 1, If S11< -10 dB then 90% of power excited is transmitted. Figure 4 shows the scattering parameter S11 of the basic of antenna which contains two bands of operation ranging from 2.3 to 3.7 GHz and 4.9 to 5.8 GHz. The antenna can be used for wireless communications applications and location-based applications.

$$S_{11}(dB) = 20 \times \log\left(\frac{P_{ref}}{P_{in}}\right) \tag{1}$$

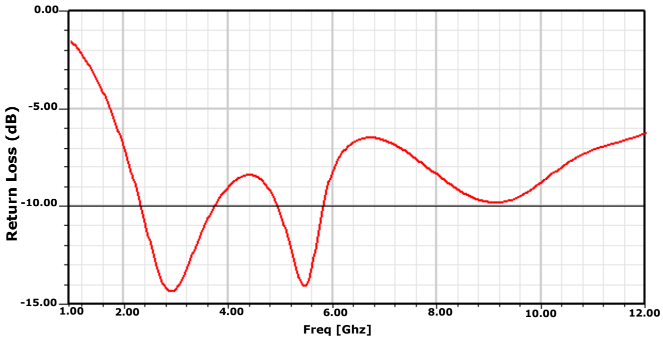


Fig. 4. Simulated return losses of the basic antenna (without slots)

The goal of the parametric study was carried out to optimize the design of the antenna. This study is very interesting because it gives unsatisfactory results before the manufacture of antenna can be made. The figure 5 presents the scattering parameter versus frequencies for different values of L1. Briefly, that the widest frequency band is getting for L1 = 0 mm

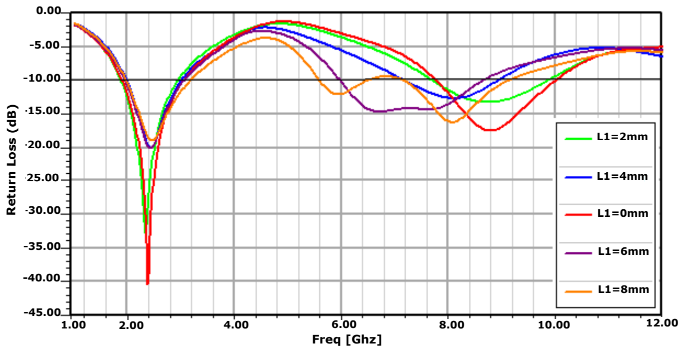


Fig. 5. Simulated return losses for different values of L1

Figure 6 represents the S11 parameter versus frequencies for different values of L1. L2. The optimum result is for L1 = 0 mm; L2 = 0 mm

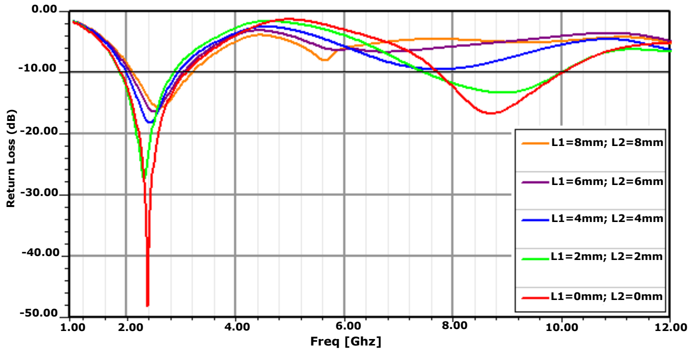


Fig. 6. Simulated return losses for different values of L1;L2

Since, the antenna presented in figure (7) is completed now; we can compare S11 of the antenna without slots, and the proposed antenna with slots. For the obtained antenna, we end up with two modes of resonances centered on the 2.4 GHz frequency and 9 GHz

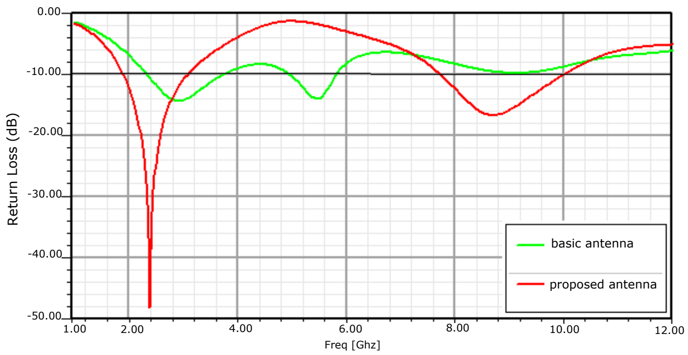


Fig. 7. Simulated return losses of the proposed and the basic antenna

Figure 8 illustrates the gain comparison between proposed and the basic antenna. We observe that the two slots do not have a large impact on the antenna gain and the maximum value of the basic antenna and the proposed came out of 2.4 GHz

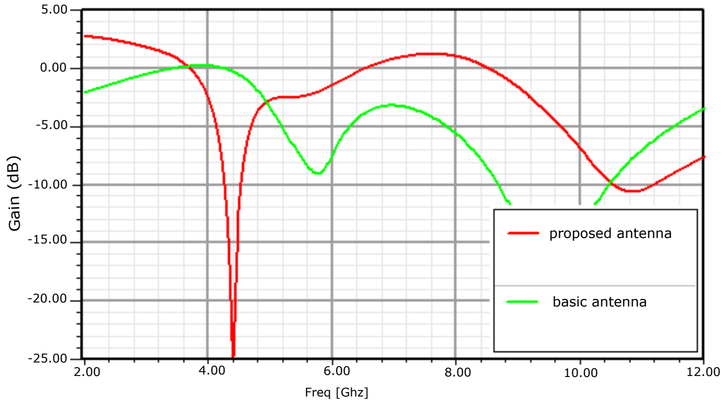
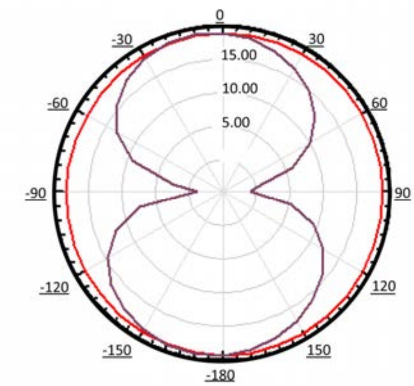


Fig. 8. Simulated gain of the proposed dual band antenna and the basic antenna

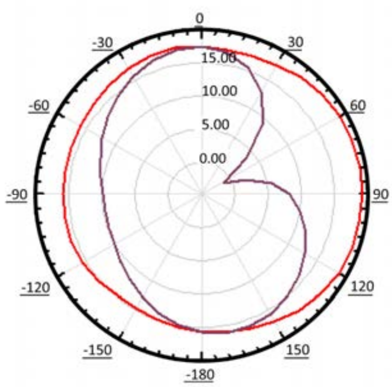
The performances of three antenna geometries reported in this paper are summarized in Table -2. As shown in this table, the gain of antenna even after modifications is still very low. Low gain and efficiency values of these antennas are perhaps due to application of glass epoxy FR- 4 substrate material bearing large loss tangent value. The final proposed antenna is more powerful in term of return loss and more adapted for the resonance frequencies

Table 2. Comparison between performances of different antenna geometries

Geometry	Resonance Freq. [GHz]	Material	RL[dB]	Gain [dB]
Antenna: CRMPA	2.4	RO4003C400 εr = 3.4 H=1.524 mm	-15.75	5.1
Antenna without slots Basic antenna	2.8	FR4 εr = 4.4 H=1.6 mm	-14	-1
Antenna proposed	2.4	FR4 εr = 4.4 H=1.6 mm	-40	2.5



(a)



(b)

Fig. 9. The radiation patterns in 2D:(a) 2.4 GHz and (b) 9 GHz

The figure 10 shows the 3D radiation pattern.

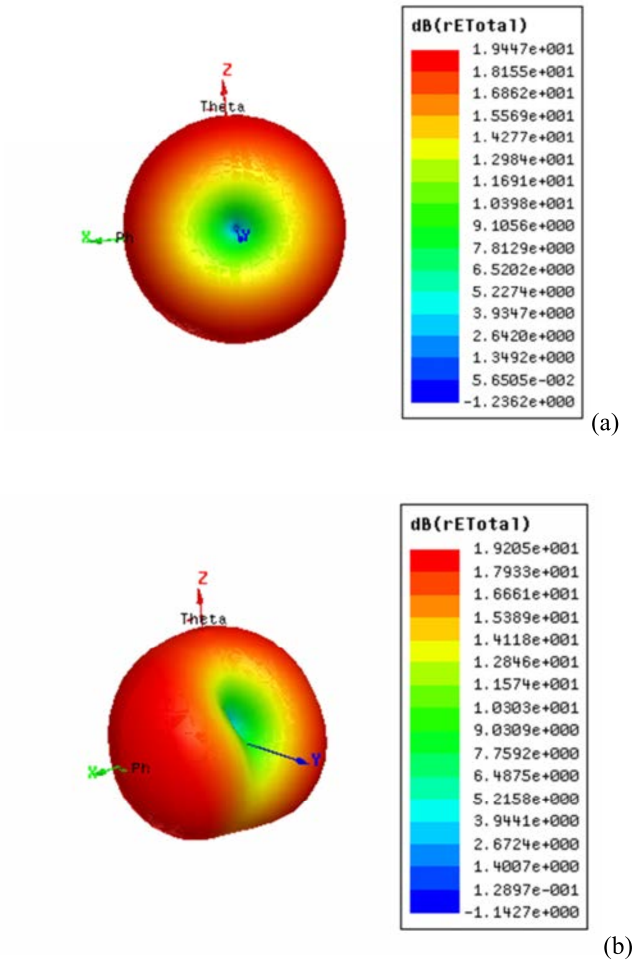


Fig. 10. The radiation patterns in 3D: (a) 2.4 GHz and (b) 9GHz

4. Conclusion

In this paper, a new patch antenna in the form of a dollar-symbole was presented, that radiates between 1.9 to 3 GHz and 7.8 to 10 GHz. The proposed antenna presents almost omni-directional in plan E and bi-directional radiation diagrams in plane H. Finally, we have shown that the presented antenna is valid for wireless (WLAN) applications; location-based applications due to its miniature size also its good performances. The dual-band antennas can be useful in many wireless applications that include two different frequency bands for receiving and transmitting.

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