NEW DESIGN OF MICRO-STRIP PATCH ANTENNA FOR WI-FI APPLICATIONS

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Abstract: In this research, a new design of a semi-star patch antenna is simulated for Wi-Fi applications. The antenna is operated at 2.4GHz, which is modified by inserting rectangular slots in the ground layer. Copper is used for the patch and ground layers, while FR-4 epoxy is used for the substrate layer. FR-4 epoxy has a $\epsilon_r = 4.3$ and a loss tangent ($\tan\delta$) of 0.025. The antenna size is (45x48x1.6) mm³. The proposed antenna provides a reflection coefficient of -41.5 dB and a gain of 2.8 dB at the operating frequency. The proposed antenna is simulated by CST STUDIO SUITE 2019.

Keywords: *Micro-strip, Patch, Return loss, Wi Fi, Feedline, CST.*

1. Introduction

In latest years, the development of communication systems has necessitated the development of antennas that are compact, high performing, light in weight, and low in cost [1]. Wireless systems include different types, such as television broadcasting, mobile communications, radar, satellite communications, landing systems, and many others, and the antenna is an essential component in these systems [2]. The general performance method of the system depends on the design of the antenna, and on the basis of the radiation of the antenna. Also, the latter is classified as anisotropic or isotropic. In wireless personal communications (WPC), reception and transmission can take place via the same

antenna or via separate antennas. The antenna is a communication device that can be carried by anyone and transported from one place to another. As a result, tiny antennas conspicuous from one end without a wire connection are required. There are several uses for antennas in wireless technologies such as Wi-Fi, Wi-MAX, and GPS [3]. There are many types of antennas, such as unipolar and bipolar antennas, horn antennas, lens antennas, wide pole antennas, correction antennas, etc. Also, patch antennas include printed antennas, short correction antennas and so on. Due to the ease of printing the patch antenna on electrical circuits, it has become widely used in wireless communications [4]. The Microstrip patch antenna (MSPA) contains a dielectric substrate placed between a patch which is the radiating part and the ground plane. The patch may take many shapes, like rectangular, or circular, or a diamond. Additionally, it could have been made of a conductive material such as gold or copper. It is usual for the patch to have a feed line photo etched over the substrate [5-7]. There are multiple ways to feed MSA, including double slot feeding, line feeding, internal feeding, and experimental paired feeding [8, 9]. The size of the ground and the substrate is

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considered larger compared to the length and width of the patch, i.e. its size, which depends on the operating frequency and the type of material used for the substrate, i.e. the dielectric constant for that material [2, 10]. There are many related work is dealing with the MSPA and its application in the different systems. Weng et al. [11] developed an MSPA 2.4 GHz antenna using (DE) differential evolution and the antenna dimensions are 50mm in length, 50mm in width and 1.6 in thickness. Whereas the antenna can be used as an antenna for personal computers and routers indoors. While Nyunt [3] conducted a study on the fundamentals of the MSPA antenna and the design of a 2.4 GHz antenna for Wi-Fi applications. Antenna size (28.28 x 48.28 x 1.6) mm and usage of FR-4 epoxy with 4.4 dielectric constant. In [12], the designer proposed an antenna that could operate at 2.4 GHz and 5.2 GHz using a partial ground and a square slotted patch. As for the substrate, it is made of FR-4 material, with a dielectric constant (ϵ_r) of 4.6, a length of 29 mm, a width of 30 mm and a thickness of 2.4 mm. Furthermore, the researchers suggested an MSPA antenna used for Wi-Fi applications with a frequency of 4.9 GHz and dimensions (24x25) mm² and a substrate with a thickness of 2.4 mm of FR-4 with a ϵ_r of 4.4 [10]. Moreover, the researchers, in [13], have proposed an MSPA antenna working at a frequency of 2.4 GHz with a large signal strength for outdoor and indoor communication and at a low cost when compared with commercial alternatives. In this research work, a new shape for the patch antenna was designed to operate at 2.4GHz for Wi-Fi applications.

2. The proposed Antenna:

The proposed antenna employs the transmission line model of an MSPA with many slots in the ground and a patch.

Figure 1. The suggested antenna (a) The patch and (b) the ground

The required design equations are as follows [10, 14,15]:

$$f_r = \frac{c}{2Wpa} \sqrt{\frac{2}{(1+\epsilon_r)}} \quad (1)$$

Where f_r = operating frequency, Wpa = patch width , c = the light speed and ϵ_r is the dielectric relative constant.

And the actual length of patch L_{pa} is expressed by

$$L_{pa} = L_{eff} - 2\Delta L \quad (2)$$

ϵ_{reff} is the effective relative dielectric constant, which is expressed by

$$\epsilon_{reff} = \frac{(\epsilon_r+1)}{2} + \frac{(\epsilon_r-1)}{2} [1 + 12 h/Wpa]^{-1/2} \quad (3)$$

Length extension (ΔL) is obtain from (4)

$$\Delta L = 0.412 \frac{(\epsilon_{reff} + 0.3)(Wpa + 0.264h)}{(\epsilon_{reff} - 0.258)(wpa * h + 0.8)} \quad (4)$$

$$L_{eff} = \frac{c}{2 f_r \sqrt{\epsilon_{reff}}} \quad (5)$$

L_{eff} is the effective length of rectangular patch.

$$Wgr = 6h + Wpa \quad (6)$$

$$Lgr = 6h + Lpa \quad (7)$$

Where Wgr is the ground width, Lgr is the ground length, and h is the substrate thickness. The width of the substrate (Wsu) is frequently equal to the width of the ground, and the length of the substrate (Lsu) is frequently equal to the length of the ground in most situations. There are multiple ways to feed MSA including double slot feeding, line feeding, internal feeding, and experimental paired feeding. In this work, a micro strip line feeder is used with a $Z_0 = 50 \Omega$ [8, 9,16]. The proposed antenna employs the transmission line model of an MSPA with many slots in the ground. The antenna is designed on an FR-4 substrate with a thickness of 1.6 mm, a relative dielectric constant and the size of the antenna. Table. 1 shows the parameter values after parametric study.

Table 1. The value of antenna parameters After parametric study

MSPA Parameters	Symbol	Value in mm
Substrate width	Wsu	48
Substrate length	Lsu	45
Ground width	Wgr	48
Ground length	Lgr	45
Dielectric relative constant	ϵ_r	4.3

3. Simulated Results

The variation of return lose (S_{11}) with frequency of the suggested antenna is seen in Figure 2 which shows that the value S_{11} is -41.5 dB at $f_r = 2.4$ GHz. Also the real part

and imaginary part of the impedance is shown in Fig. 3. The 3-D far field radiation pattern of the antenna is seen in Figure 4. The surface current distribution of suggested antenna is seen in Figure 5. And Figure 6 (a & b) shows radiation pattern of antenna at $f_r = 2.4$ GHz. Figure 7 shows the variation of the gain with frequency, it is noticed that the proposed antenna gain is 2.8 dB at 2.4 GHz. Additionally, Figure 8 displays the group delay is 2.9 ns at 2.4 GHz.

Figure 2. Return loss (S_{11}) with frequency

Figure 3. Impedance with frequency

Figure 4. Far field 3-D radiation pattern of antenna

Figure 5. Surface current distribution for antenna

(a) h-field

(b) e-field

Figure 6. Radiation pattern of antenna **Figure 7.** The Gain for proposed antenna **Figure 8.** Group delay for proposed antenna **Figure 9.** VSWR VS. frequency

Fig. 9 shows the relationship between the frequency and VSWR of the suggested antenna, which shows that the amount of the VSWR is 1.01 at 2.4 GHz

Table 2 illustrates the comparison with three different related works.

Table 2. Comparison with previous related works

References	Dimensions mm ³	S11 dB	Gain dB	VSWR R
Ref [3]	28.28x48.28 x 1.6	-31.6	3.42	1.125
Ref [12]	29x30x2.4	-26	2.866	
Ref [10]	24x25x1.6	-22.98	2.866	1.24
Proposed antenna	45x48x1.6	-41.5	2.8	1.016

The proposed antenna has the best VSWR and S11 values, as seen in the table 2.

4. Conclusions

For Wi-Fi applications at the 2.4GHz band, a new micro strip patch antenna form has been proposed. The antenna size is (45x48x1.6) mm³ installed on FR-4 epoxy substrate with $\epsilon_r = 4.3$ and $\tan \delta = 0.025$. The reflection coefficient is $S_{11} = -41.5\text{dB}$. The antenna is simulated by CST STUDIO SUITE 2019. As a coming work, the suggested

antenna can be modified to include Wi-Fi/Wi-MAX applications.

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Conflict of interest

The authors declare that this research dose not conflict with any other work.

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