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Novel E-Shaped Microstrip Patch Antenna For Wi-Fi Application

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Abstract: In this paper, we proposed the design and simulation of an E-shaped microstrip patch antenna (ESPA) operated at 5 GHz frequency for Wi-Fi application. The antenna design consists of an E-shaped patch along with two identical rectangular slots which is used to improve the performance of antenna by compacting the antenna size. The required E-shape patch is obtained by using two parallel rectangular slots on the rectangular patch antenna. The antenna is designed on low cost substrate material of Arlon Diclad 880 of dielectric constant of 2.2 and thickness h= 3.2 mm and loss tangent of 0.0009. By using rectangular slots, the designed antenna shows resonance frequency at 5 GHz and return loss of -43.26 dB. The geometry and results of the designed antenna is obtained using Ansoft HFSS electromagnetic simulator based on finite element method. The result showed better performance of return loss < -10 dB and VSWR ≤ 2 at 5 GHz frequency.

***Keywords* — Microstrip patch antenna, ESPA, Wi-Fi, Resonance frequency, Return loss, VSWR, HFSS**

I. INTRODUCTION

In recent years, Microstrip patch antenna plays an important role in wireless communication system. A microstrip patch antenna consist of a radiating patch which is placed above the dielectric substrate and a ground plane is placed on the other side of dielectric substrate. Microstrip antennas having several advantages such as light weight, thin profile, conformal to a shaped surface, low fabrication cost and capability to integrate with microwave integrated circuit technology [1-2]. The microstrip patch antenna is very well suited for applications such as wireless communication system, cellular phone, radar aircraft and satellite [3-4]. However, the microstrip antenna has main disadvantage as it has narrow bandwidth. The bandwidth of microstrip antenna can be increased using a large number of techniques such as air substrate, slots on radiating patch and for small size antenna, a new type of dielectric material can also be used [5-6]. The Federal Communications Commission (FCC) specifies the 3.1-10.6 GHz band for UWB commercial usages in 2002. Antenna designs for UWB applications are facing many challenges like electromagnetic interference (EMI) problems, impedance matching, and radiation stability.

In previous year, the limitations of microstrip patch antenna can be overcome with several techniques like by increasing the thickness of substrate however increasing thickness of substrate increases the size of microstrip antenna or modify the shape of patch antenna by using different shapes on patch structure or introducing parasitic element. The commonly used method is to change the shape of radiating patch element such as I-shaped [7], diamond shaped monopole antennas [8], U-slot patch antennas, V-slot patch antennas and some slotting techniques are also used such as truncated corners, central patch, and hexagonal [9-11].

In this paper, a simple and compact type of E-shaped microstrip patch antenna is designed. The E-shaped antenna can be obtained by utilizing two parallels slots on the rectangular patch structure. The antenna structure has also two rectangular slots at top and bottom of the patch to give better result and enhance the bandwidth. The designed E-shaped antenna gives excellent result at 5.0 GHz frequency with -43.26 dB of return loss and designed antenna can be used for Wi-Fi application. Antenna is designed and simulated by using Ansoft HFSS simulator tool.

II. ANTENNA DESIGN

Fig.1. shows the basic layout of the rectangular E-shaped patch antenna. The rectangular patch antenna designing parameters as length (L) and width (W) are determined from the standard mathematical equations. In the proposed design, E-shaped antenna can be obtained by utilizing two parallels slots on the rectangular patch structure.

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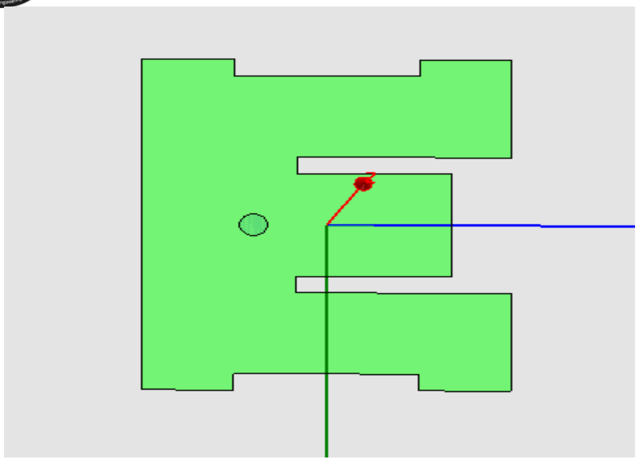


Fig.1. E-shaped microstrip patch antenna

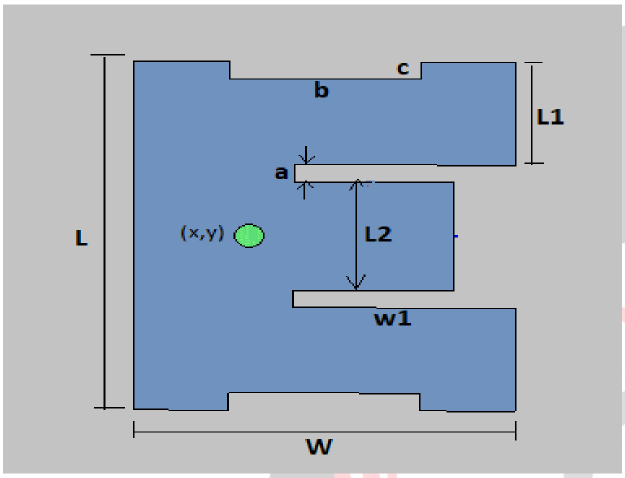
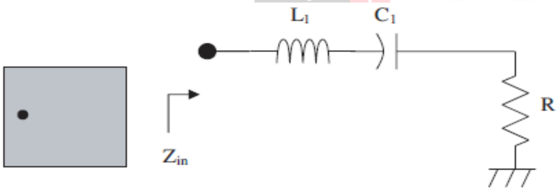
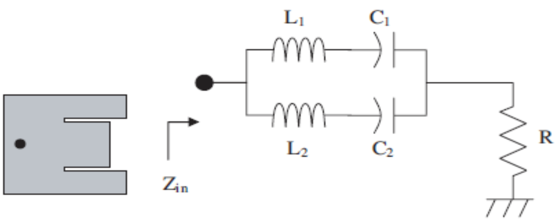


Fig.2. Geometry and dimensions of the E-shaped microstrip patch antenna



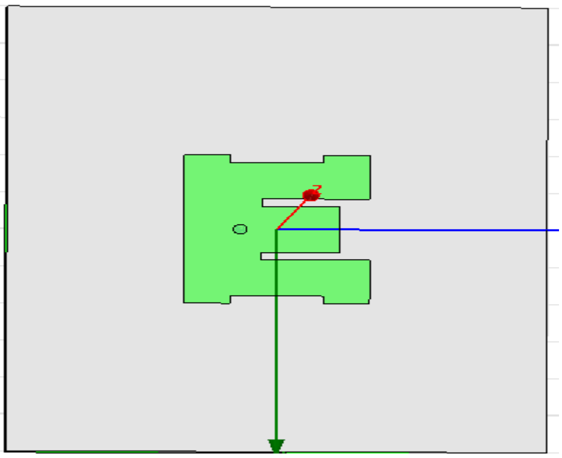
(a)



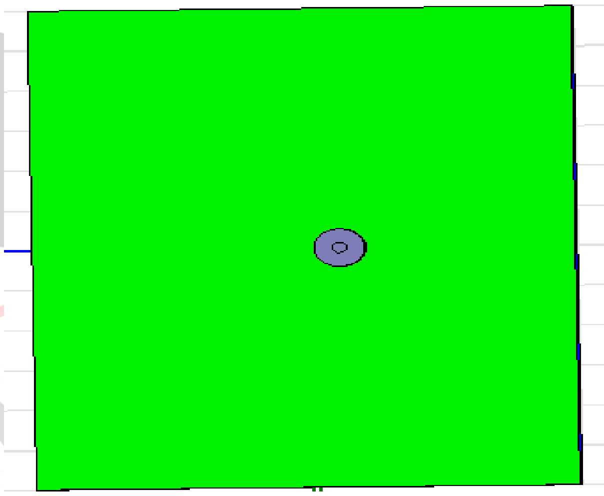
(b)

Fig.3. Equivalent circuit of (a) Rectangular patch (b) E-shaped patch antenna

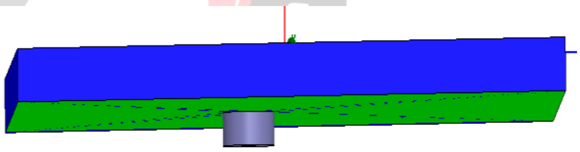
In the above fig.3, two different types of equivalent circuits are shown. In first figure, an electrical equivalent circuit of rectangular patch antenna is presented and it consist of L and C components in series form along with R. Similarly in the second figure, an equivalent circuit diagram of E-shaped microstrip patch antenna is shown. The equivalence impedance is the parallel combination of upper and lower reactance.



(a) Top view



(b) Bottom view



(c) Side view

Fig.4. Different views of antenna (a) Top view (b) Bottom view and (c) Side view

The antenna structure has two rectangular slots at top and bottom of the patch. The function of using rectangular slots is to provide better result for Wi-Fi frequency application. The proposed antenna is designed on an Arlon Diclad 880 substrate of dimension 60 mm × 50 mm. The height of the substrate h = 3.2 mm and relative permittivity of 2.2. Fig.2. shows the antenna geometry and dimensions. A rectangular patch on the front surface of the substrate with size of L ×W = 20mm × 17.2 mm. The other antenna design parameters are mentioned in Table.1.

The length (L) and width (W) of E-shaped microstrip patch antenna are calculated from the following equations

$$W = \frac{C}{2\, f \sqrt{(\varepsilon_r + 10)/_{2}}}$$

Where, C is the velocity of light, is the dielectric constant of substrate, f is the antenna working frequency, W is the

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patch width, is the effective dielectric constant.

$$\epsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 10\frac{h}{w}\right]^{\frac{1}{2}}$$

The length extension is expressed by

$$\frac{\Delta l}{h} = 0.412\frac{(\epsilon_{eff} + 0.300)\left(\frac{w}{h} + 0.262\right)}{(\epsilon_{eff} - 0.300)\left(\frac{w}{h} + 0.813\right)}$$

Then we can find the value of actual length of the patch as

$$L = \frac{C}{2 f \sqrt{\varepsilon_{eff}}} - 2\,\Delta l$$

$$L_g = 6h + L$$

$$W_g = 6h + W$$

The antenna is fed by coaxial feeding in which two cylinders are used. The radius of outer cylinder is 2.35 mm and that of inner cylinder is 0.65 mm respectively. In the design, two rectangular slots of dimension 1mm ×8.6mm.

Table 1: Proposed antenna design parameters

Parameters	Value (mm)	Parameters	Value (mm)
L	20	a	1
L1	5.9	b	8.6
L2	6.2	c	1
W	17.2	X	0
W1	10	Y	3.4

III. SIMULATION RESULT AND ANALYSIS

The simulation of designed E-shaped microstrip patch antenna is done with the help of Ansoft High Frequency Structure Simulator HFSS 11 electromagnetic simulator which is based on finite element method technique. The simulated results of the projected antenna are discussed below.

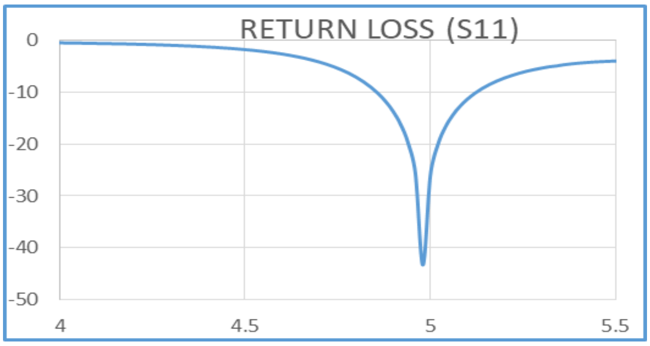

Fig.5. Simulated Return loss (S11)

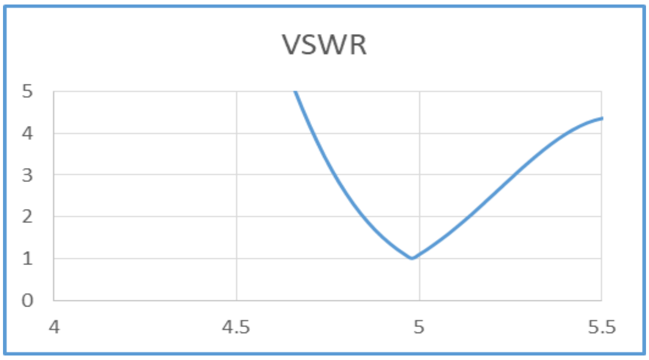

Fig.6. Simulated VSWR

The return loss (S11) of the designed antenna is shown in fig.5. The simulated return loss is -43.26 dB at 5 GHz frequency which is much below the -10 dB required value. Similarly the simulated VSWR is also shown in fig.6 which is less than 2 at the above mentioned frequency. Hence the return loss and VSWR results are achieved as per the required conditions.

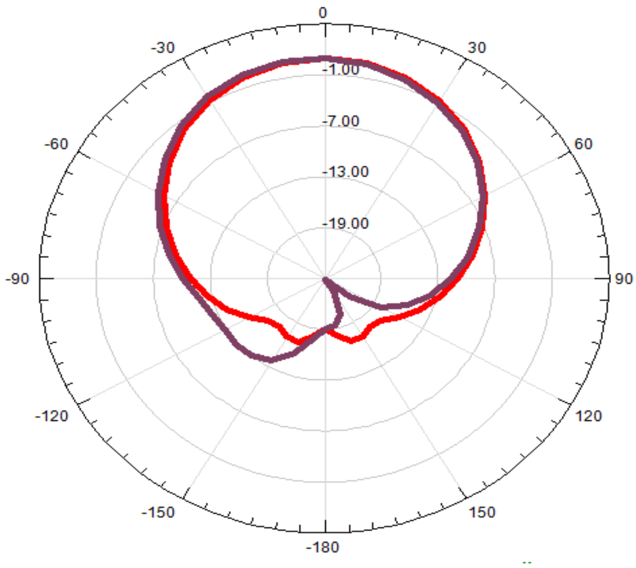

Fig.7. Far-field radiation pattern at 5 GHz

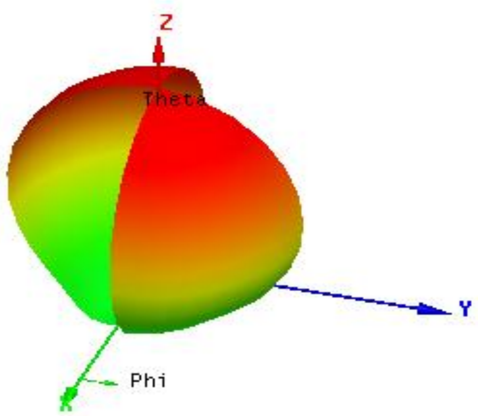

Fig.8. 3D-Polar Field Plot at 5 GHz

The simulated far-field radiation pattern is shown in fig.7. Result shows Omni-directional and stable radiation pattern as well as good impedance matching at 5.0 GHz frequency whereas fig.8 represents the polar field plot of the designed E-shaped microstrip patch antenna.

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IV. CONCLUSION

In this paper, a novel E-shaped microstrip patch antenna (ESPA) is designed and simulated for Wi-Fi application operated at 5 GHz frequency. From the simulated result, the designed antenna almost radiates omnidirectional and stable radiation pattern at 5.0 GHz with excellent return loss, VSWR and gain for Wi-Fi application. The reflection coefficient of designed antenna is -43.26 dB which is much better than required value. The performance of designed antenna is excellent and meeting the required parameters and resonant at Wi-Fi frequency.

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