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Design A Rectangular Microstrip Patch Antenna for WLAN Application

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***Abstract* - This paper presents a rectangular microstrip patch antenna for WLAN applications operating in a single band of frequency 2.4 GHz. Design and simulation processes are carried out with the aid of the HFSS (High Frequency Structural Simulator). The proposed antenna is designed on a 1.59 mm thick Rogers TMM 4 (tm) with a relative permittivity of 4.5. and achieve a gain of 4.96 dB with a return loss of -27.50 dB. The key parameters like -Return loss, Input impedance, Gain are simulated, analyzed and optimized using HFSS v12.1.**

Keywords- Microstrip Antenna, Co-axial probe feed, S Parameter, Return loss, Gain, VSWR (voltage standing wave ratio), WLAN, Ansoft HFSSv12.1

INTRODUCTION

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. The EM waves firing off the top patch into the substrate and are radiated out into the air after reflecting off the ground plane. The feed of microstrip antenna can have many configurations like microstrip line, coaxial, aperture coupling and proximity coupling. But microstrip line and the coaxial feeds are relatively easier to fabricate. However, the microstrip line limits the bandwidth to 2 to 5% as spurious radiation increase with the increase in the substrate thickness. Therefore, we are using coaxial feed [1].

The IEEE 802.11 standard was proposed in 1997 for WLANs application. After few years new standard was proposed operating on the 2.4 GHz ISM band (2.4-2.484 GHz) ,is called 802.11b or 802.11 HR(High Rate), which provides a data rate up 11Mbps.The IEEE 802.11y standard was approved in 2008,operating on the 3.6 GHz frequency. The IEEE 802.11a standard was approved in 1999, operating on the 5 GHz ISM band (5.15-5.35 GHz and 5.725-5.825 GHz. The change of band shows that 802.11a and 802.11b products are not compatible. Therefore, the IEEE proposed 802.11g standard which is compatible with both 802.11b and 802.11a technology. The 802.11g standard was accepted in 2003.since 802.11b and 802.11g are using 2.4 GHz frequency band .So a dual band antenna is requirement for WLAN application [2].

The microstrip patch antenna has the advantage of low profile, light weight, small size and low cost. But the main disadvantage associated with microstrip antenna is their narrow bandwidth.

In this paper a compact size rectangular microstrip patch antenna is proposed using dielectric substrate as Rogers TMM 4 (tm) with ε_r =4.5 and all the dimensions are based on resonant frequency. Various attempts are made to adjust the dimensions of the patch to improve the parameters like bandwidth, return loss, gain along θ, Ø direction, radiation pattern in 2-D and 3-D, E and H field Distributions , current Distributions using HFSS 12.1.

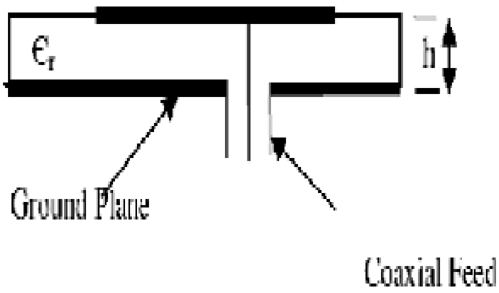

Fig.1- Co-axial feeding technique

DESIGN SPECIFICATION

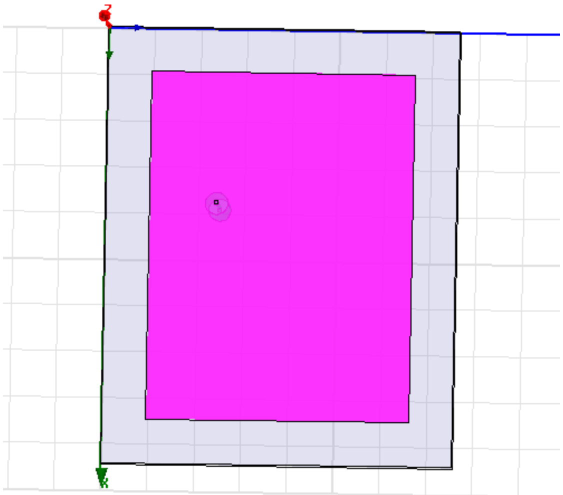

Fig 2- Designed rectangular microstrip patch antenna

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The antenna is simulated on Rogers TMM4 substrate with a dielectric constant of 4.5, the thickness of substrate is 1.59 mm. The length and width of the antenna can be calculated by transmission line method as given below

Width of antenna is given by

$$W = \frac{c}{2.f_c\sqrt{\frac{\varepsilon_r+1}{2}}} \quad (1)$$

The effective dielectric constant

$$\varepsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{-0.5} \quad (2)$$

The extension length is given by

$$\Delta L = 0.412*h*\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \quad (3)$$

The effective length is given by

$$L_{eff} = \frac{c}{2.fc\sqrt{\varepsilon_{reff}}} \quad (4)$$

Therefore the actual length of the patch is calculated by

$$L = L_{eff} - 2\,\Delta L \quad (5)$$

By substuting the value of operating frequency 2.4 GH_Z, C = 3×10^8m/s, ε_r = 4.5 and h = 1.59mm the width of the patch (W) becomes 37.68 mm and Leff = 30.60 mm, substituting ε_{eff} = 4.17 and the values of W and h, we get ΔL = 1.2244 mm. In final, we obtain the length of the patch using this equation.

$$L = Leff - 2\Delta L \quad (6)$$

L = 30.60 mm – 2.4488 mm = 28.35 mm.

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. Similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the ground plane dimensions would be given as:

$$L(g) = 6h + L \quad (7)$$

L (g) = 6*(1.59 mm) + 28.35 mm = 37.89 mm

$$W(g) = 6h + W \quad (8)$$

W (g) = 6*(1.59 mm) + 37.68 mm
= 47.22 mm

Hence after calculating all the parameters using the above formulae, the rectangular microstrip patch antenna was designed.

Table 1- Antenna dimensions

Frequency	2.4 GHz
Height	1.59 mm
Dielectric constant	4.5
Width of patch (W)	37.68 mm
ε_{reff}	4.17
Extension length (ΔL)	1.2244 mm
Length of patch(L)	28.35 mm

SIMULATION RESULTS

The simulated result of variation in S_{11} parameter as a function of frequency for the proposed antenna is shown in fig.3.This antenna is working on the frequency of 2.4 GHz and the obtained Return Loss of -27.50 dB.

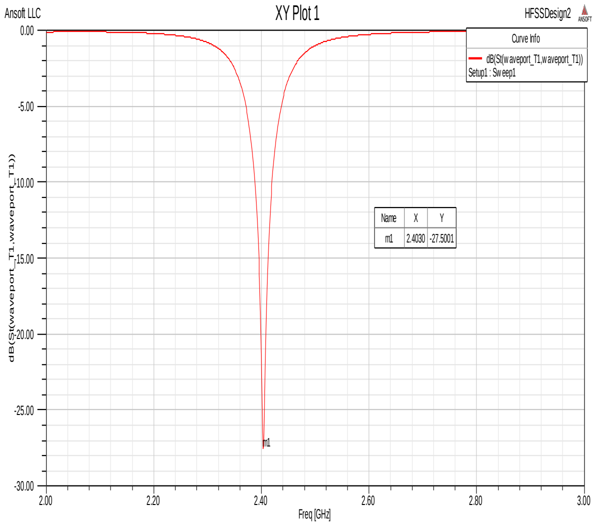

Fig.3 – Return loss of design antenna

The VSWR of rectangular microstrip patch antenna is shown in Fig, 4. The value of VSWR should be less than 2. Here the value of VSWR for the proposed microstrip antenna is 0.7421 at the specified resonating frequency.

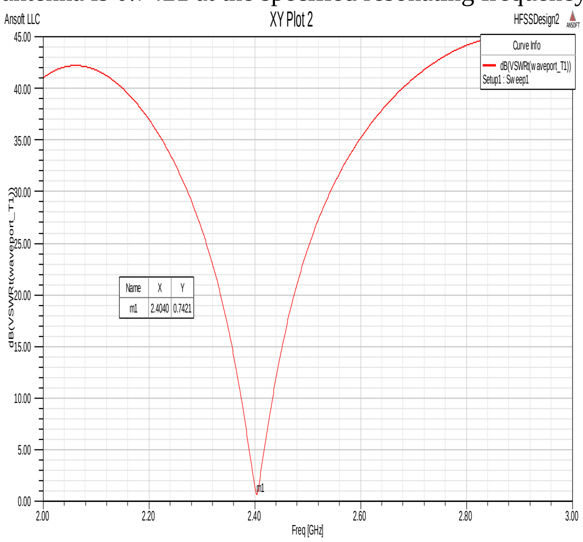

Fig.4- VSWR of design antenna

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Fig 5 and 6 show the simulated E-plane gain pattern and radiation pattern for the proposed antenna. In this design a gain of 4.96dB have been investigated at the resonating frequency.

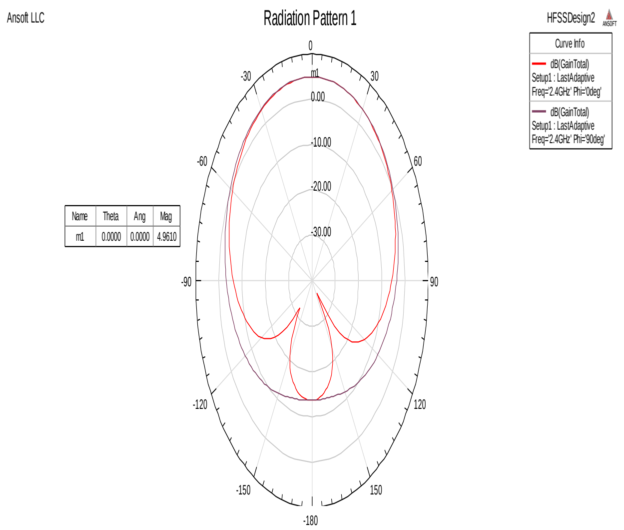

Fig.5- Gain pattern of design antenna

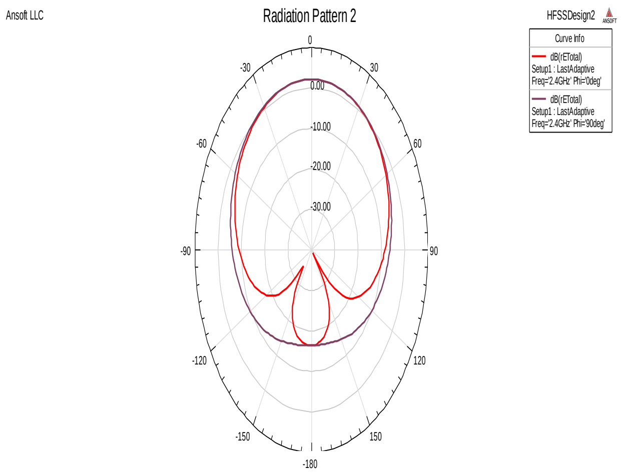

Fig.6- Radiation pattern of design antenna

CONCLUSION

In this paper, a small size Microstrip patch antenna for WLAN application by using co-axial probe feed technique is designed. The simulation is carried out using Ansoft HFSS v 12.1 software. The Return loss of 27.50 dB and Gain of antenna is 4.96 dB. VSWR is 0.7421. The results shows that the proposed antenna suitable for WLAN applications.

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