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Design of a Tri Band H-Shaped Microstrip Patch Antenna for L, C and X-Band Application

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Abstract: In this paper, a tri-band H-shaped rectangular microstrip patch antenna is presented for L, C and X-band applications. The proposed antenna has symmetrical properties and operating in a tri-band of frequency 2.4 GHz. In this paper H-shaped patch antenna is designed on a 1.56 mm thick Rogers TMM 4(tm) substrate with a relative permittivity of 4.5 and achieve a gain of 6.52dB. The simulation process has been done using HFSS v12.1 (High Frequency Structural Simulator). The key parameters like Return loss, VSWR, Gain are simulated, analyzed and optimized using HFSS v12.1.

Keywords: Tri band antenna, Microstrip antenna, Co-axial probe feed, S parameter, Return loss, VSWR, Gain, Ansoft HFSSv12.1.

I. INTRODUCTION

The pattern and relationships between species in the early 1990s, WLAN (Wireless Local Area Network) were very expensive and were only used when wired connections were strategically impossible. In the late 1990s, most of the WLAN solutions and proprietary protocols were replaced by IEEE 802.11 standards [1]. Amicrostrip patch antenna consist 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. Microstrip antenna feed can have many configurations such as microstrip line, coaxial, aperture coupling and proximity coupling. But the microstrip line and the coaxial feeds are relatively easier to fabricate [2]. A good design of the antenna can relax system requirements and improve overall system performance. Digital Communication System works at a frequency of 1.71 GHz-1.88 GHz, Wireless Local Area Network works at a frequency of 2.4-2.474 GHz, 5.15-5.35 GHz, 5.475-5.725 GHz, 5.725-5.825 GHz and X band frequency range is 8-12 GHz. The microstrip patch antenna has the advantage of low profile, small size, light weight and low cost. In this paper a compact size H-shape microstrip patch antenna is proposed using dielectric substrate as Rogers TMM4 (tm) with ε_r =4.5 and all the dimensions are based on resonant frequency. Figures 1 demonstrate the co-axial feeding technique.

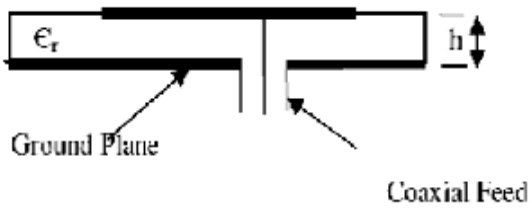

Fig. 1 Co-axial feeding technique

II. ANTENNA DESIGN

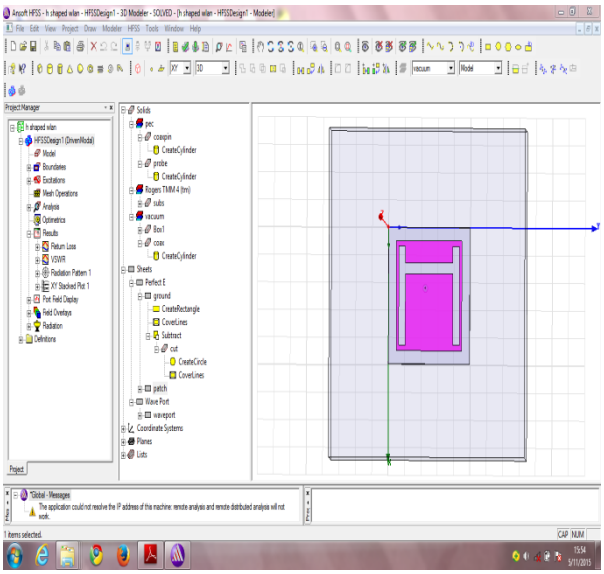

Fig. 2 Designed H-shape microstrip patch antenna

The antenna is simulated on Rogers TMM4 (tm) substrate with a dielectric constant of 4.5, the thickness of substrate is 1.56 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

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

The extension length is given by

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

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The effective length is given by

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

Actual length of the patch is calculated by using eq. (3) and (4) and given 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, $\boldsymbol{\varepsilon}_r$ = 4.5 and h = 1.56mm the width of the patch (W) becomes 38.03 mm and Leff = 30.89mm, substituting ε_{eff} = 4.09 and the values of W and h, we get ΔL = 0.736 mm. In final, we obtain the length of the patch using this equation.

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

L = 30.890 mm – 1.478264 mm = 29.417 mm

The transmission line model is applicable to infinite ground planes only. But, for practical considerations, it is necessary to have a finite ground plane. The 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. Therefore, for this design, the ground plane dimensions would be given as:

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

L(g) = 6*(1.56 mm) + 29.417mm = 38.77mm

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

W(g)= 6*(1.56 mm) + 38.03 mm = 47.39mm

After calculating all the parameters using the above formula, the rectangular microstrip patch antenna was designed.

Table 1 Dimensions of Antenna

Frequency	4.5GHz
Height	1.56mm
Width of patch (W)	38.03mm
Dielectric constant	4.5
Extensionlength(ΔL)	0.736mm
ε_{reff}	4.09mm
Length of patch(L)	29.41mm

III. SIMULATION AND ANALYSIS

The simulation is done in HFSS 12.1 (High Frequency Structural Simulator). The simulated result of variation in S11 parameter as a function of frequency for the proposed antenna is shown in fig. 3. The noted Return Loss at 1.79 GHz, 5.23 GHz, 5.93GHz and 9.26 GHz are -18.56dB,-19.50dB, -41.29dB and -26.73dB respectively.

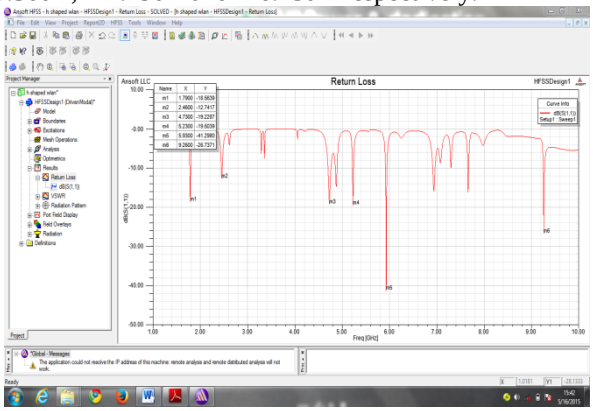

Fig. 3 Return loss of design antenna

Fig. 4 shows the VSWR of H-shape microstrip patch antenna. The value of VSWR should be less than ≤ 2.

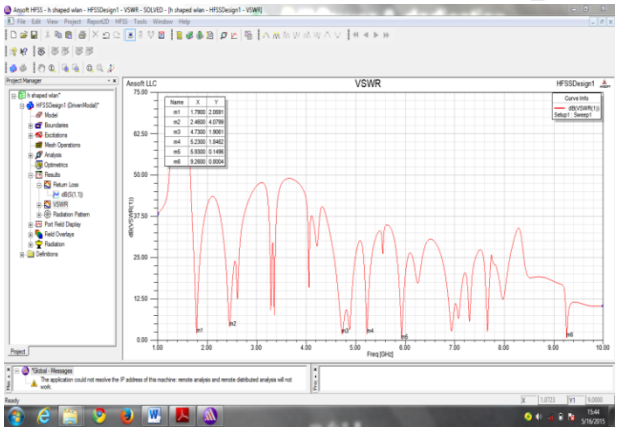

Fig. 4 VSWR of design antenna

Fig. 5 Demonstrate the simulated E-plane gain pattern for the proposed antenna. In this design gain of antenna 6.5266dB have been investigated for the resonating frequency.

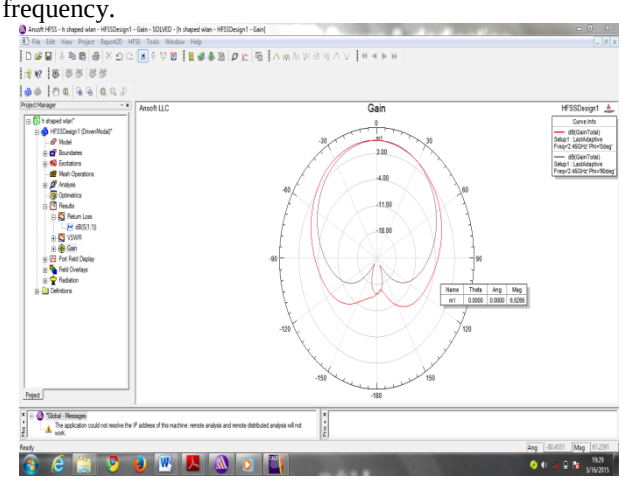

Fig. 5 Gain pattern of design antenna

IV. CONCLUSION

In this paper, design of a small size H-shape microstrip patch antenna for L,C and X band application by using co-axial prove feed technique. The simulation is carried out using Ansoft HFSS v 12.1 software. The Return loss is less then -10 dB and Gain of antenna is 6.5266 dB. VSWR is obtained ≤ 2, which is suitable for antenna design.

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