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Design of Reconfigurable Microstrip Patch Antenna for WLAN Application

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Abstract-In this paper we propose a rectangular microstrip patch antenna with inset fed which can operate at 2.4 GHz (IEEE 802.11b) & 5.8 GHz (IEEE 802.11a) WLAN applications. Various slot is cut into the antenna structure which changes the surface current path resulting in dual resonant frequency. Further by embedding any switch into a slot, reconfiguration can be achieved i.e. the antenna can only be used in unlicensed 2.4 GHz band. The achieved directivity is greater than 5db and the bandwidth obtained is much greater than the required bandwidth. The proposed antenna is simulated using High Frequency Structure Simulator.
Keywords- Reconfigurable microstrip patch antenna, slots, switches, dual band, resonant frequency.

I. INTRODUCTION

Reconfigurability has become a crucial feature in modern wireless communication world. With the help of a single antenna more than one frequency bands, radiation pattern & polarization can be obtained. With recent developments in technology operating an antenna for multiple bands can be considered as key advances in modern wireless communication. Slots can be cut of various shapes i.e. U slot, V slot, and rectangular slot inside the patch for achieving multiple bands [3]. Reconfiguration can be achieved using various techniques such as electrically by using switches (PIN diode, varactor), by optical switches, physical altering the antenna structure, change in substrate characteristics (Meta materials) [4].

In this paper a reconfigurable microstrip patch antenna with inset feed is proposed which can operate at different frequency having an application for WLAN. Dual band can be achieved by cutting parallel slots into the structure. PIN diode switch is used in this case which when operates in ON condition and placed at optimized position helps to achieve a single band. The directivity observed at both frequency bands is greater than 5db which is good enough for real time applications [7].

II. ANTENNA DESIGN

Initially the antenna is designed for 2.4 GHz resonant frequency. FR-4 substrate with permittivity (εr) =4.4, loss tangent = 0.079 and of height 1.6 mm is used. For impedance matching simple inset feed technique is used in this case.

The formula used for designing the antenna are as follows by using [2].

$$W=\frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (1)$$

$$\in r_{eff} = \frac{\epsilon_r+1}{2}+\frac{\epsilon_{r-1}}{2}\left[1+12\frac{h}{W}\right]^{-1/2} \qquad (2)$$

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

$$L_{eff} = L + 2\Delta L \qquad (4)$$

$$L = \frac{1}{2f_r\sqrt{\epsilon_{reff}}\sqrt{\mu_0\epsilon_0}} - 2\Delta L \qquad (5)$$

The length and width of the substrate is calculated by equation (6) & (7) by using [1].

$$W_g = 6h + W \qquad (6)$$

$$Lg = 6h + L \qquad (7)$$

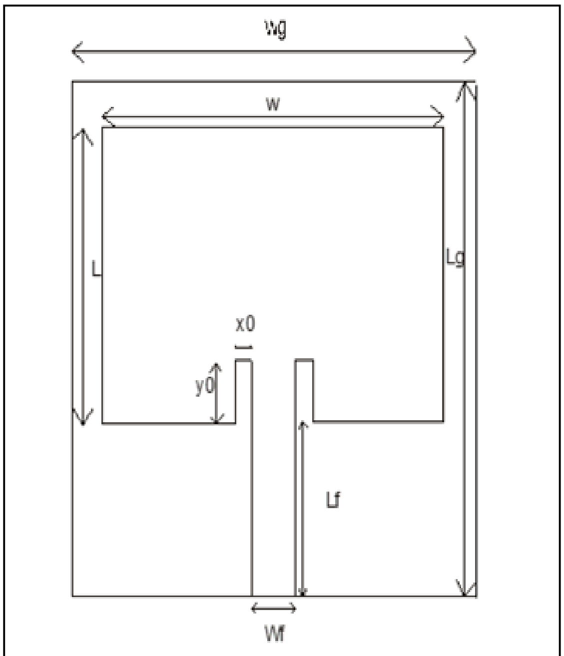

Figure 1. Simple microstrip patch antenna with inset feed

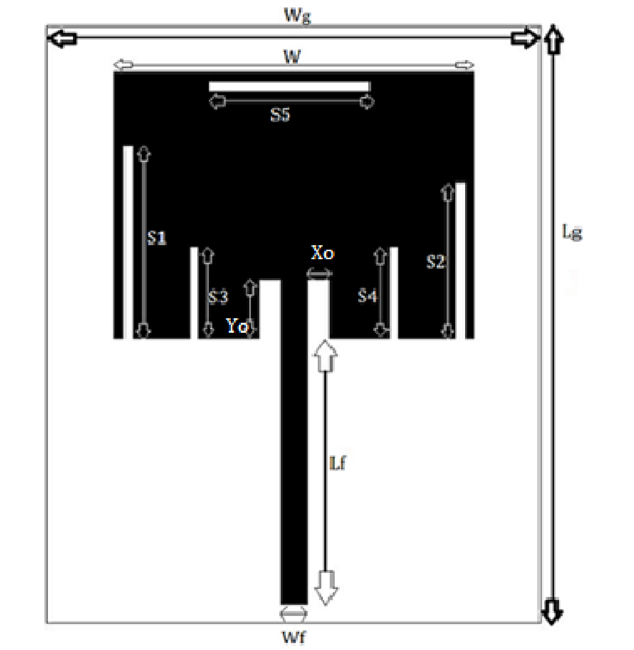

Figure 2. Antenna with various slots to obtain dual-band frequency

Two parallel slots of different lengths are inserted closer to the non-radiating edges. Then two slots of equal length are inserted parallel to bring the desired dual band at 2.4 & 5.8 GHz as shown in Fig 2. The parallel slots alters the surface current path which introduces a second resonant frequency due to the inductive effect. Introduction of slot inside the microstrip patch antenna does not increase the patch size or changes the radiation pattern but changes the input impedance of antenna. Thus with further addition of a horizontal slot, S11 response is recorded well below -10 dB at both 2.4 GHz & 5.8 GHz.

After obtaining a dual band at 2.4GHz & 5.8GHz for WLAN application our next step is to switch the frequency to a single band. By application of a switch at the centre point of slot 1 as shown in Fig 3 the dual band antenna changes its characteristics and again starts behaving as a single band antenna. When the switch is OFF the antenna gives a dual band at 2.4GHz & 5.8 GHz but when the switch is turned ON the 5.8 GHz band is eliminated and a single resonant frequency at 2.4 GHz is obtained.

The design parameters used in designing the proposed antenna is given below in Table I.

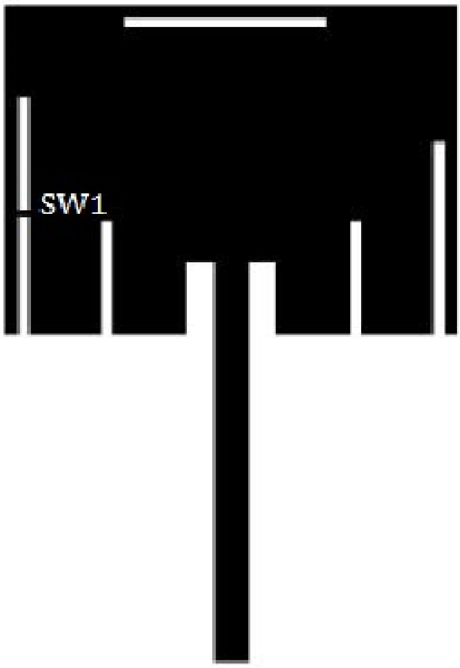

Figure 3. Antenna structure after implementing switch

Table I. ANTENNA DESIGN PARAMETERS

Parameters	Calculated Length	Calculated Width	Optimized length	Optimized Width
patch	29.8	38.39	29	38
substrate	39.8	48.39	65	52
Feed	29	3.1	33	2.8
inset	9.71	2.42	6.4	2.4
Slot 1(s1)	OPTIMIZED		21	1
Slot2(S2)			17	1
Slot 3(s3)			10	1
Slot 4(s4)			10	1
Slot 5(s5)			19	1
Switch(sw1)			1	0.5

III. RESULT

The simulation results of antenna without switches and with switches are shown in Figs. 4 & 5. The obtained return loss at 2.4GHz and 5.8GHz are -33.2 dB & -22.1 dB respectively. The bandwidth obtained at 2.4GHz & 5.8 GHz are 160MHz & 150MHz which is greater than the required bandwidth. When the switch is ON, a single band is obtained at 2.4 GHz with a return loss of –20 dB. The obtained gain at 2.4 GHz & 5.8 GHz are 2.9dB & 1.1 dB respectively as shown in Figs. 6 and 7 below.

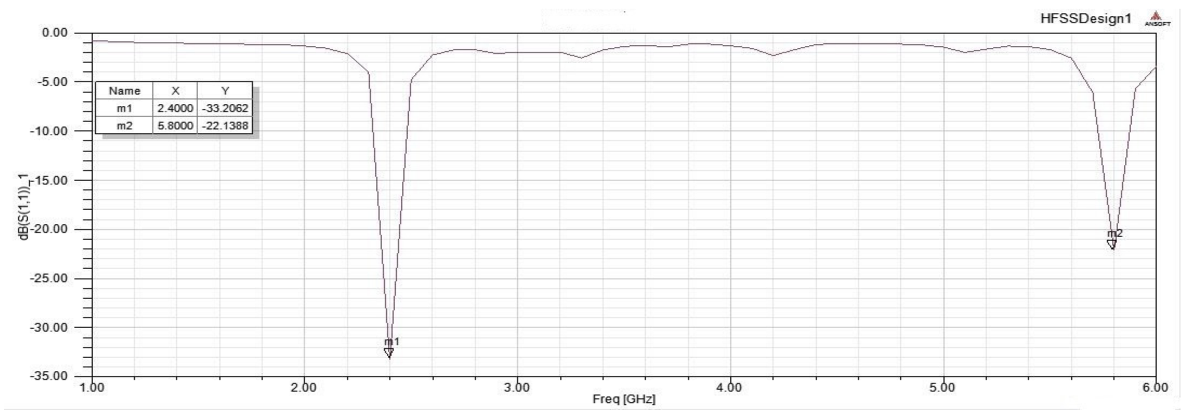

Figure 4. Return loss graph when switch is OFF.

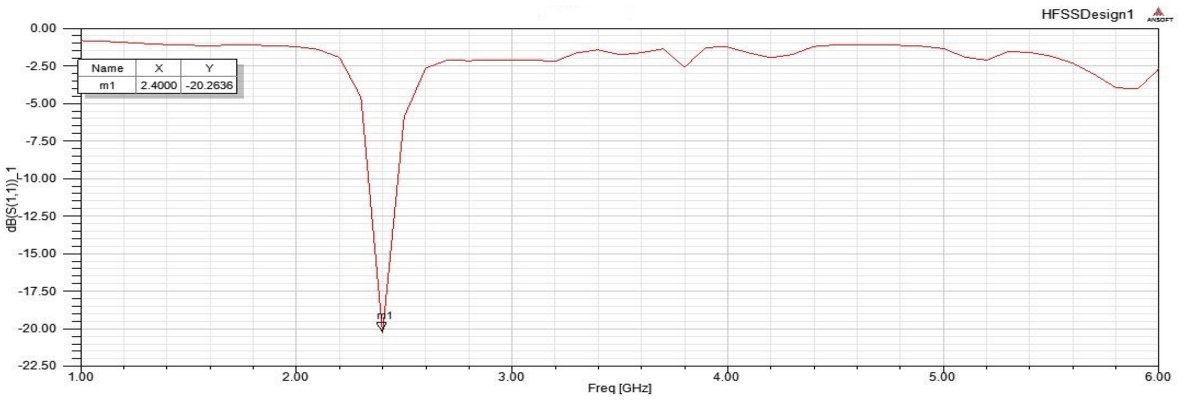

Figure 5. Return loss graph when switch is ON.

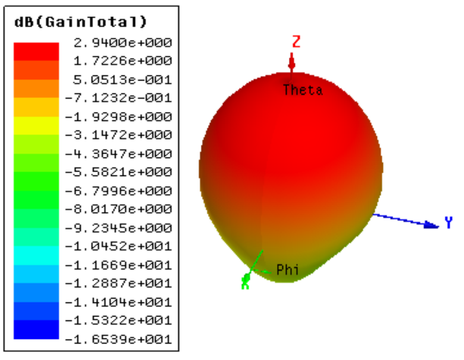

Figure 6. Antenna gain at 2.4 GHz

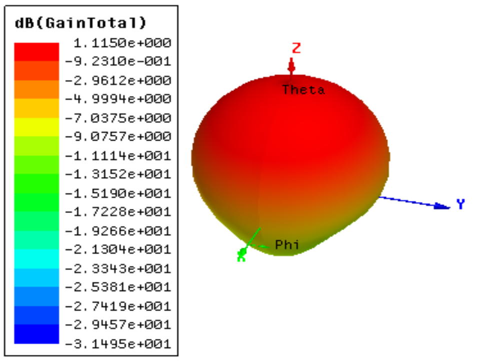

Figure 7. Antenna gain at 5.8 GHz

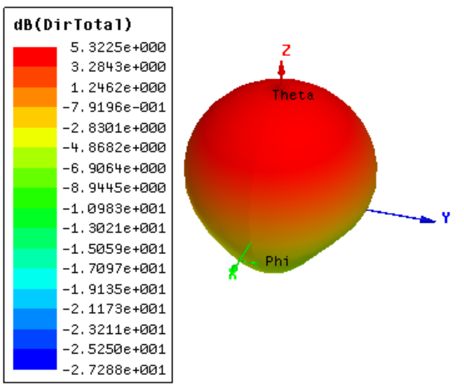

Figure 8. Directivity at 2.4 GHz is 5.32 dB

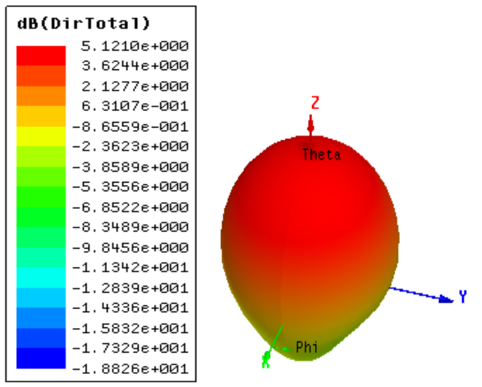

Figure 9. Directivity at 5.8 GHz is 5.12 dB

IV. CONCLUSION

A reconfigurable antenna for WLAN application is designed with the help of HFSS software. Dual-band at 2.4 GHz & 5.8 GHz is obtained with directivity above 5dB and bandwidth greater than 100MHz. The frequencies can be switched by application of any RF or MEMS switches into the antenna. The obtained directivity at both the band is above 5dB i.e. 5.32dB & 5.12 dB at 2.4 GHz & 5.8 GHz respectively. More work in future would include improvement of antenna gain and reduction in size of the antenna.

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