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Dual Band Microstrip Patch Antenna for Short Range Wireless Communications

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Abstract: This paper describes the design and development of a simple patch antenna for dual band operations. The dualband operation is obtained by embedding a rectangular shaped slot in the radiating patch. The dielectric material used is FR4 substrate with the dielectric constant of 4.4 having thickness h =1 mm and a microstrip line feeding method is used. The entire size of the antenna is only 13.47x17.52x1mm^3.The simulation was performed using Advanced Design System (ADS) software.This antenna is operating in IEEE 802.11a frequency range (5.2/5.8GHz). Furthermore, the proposed antenna has a low profile, making it suitable for wireless handheld devices and thus suitable for short range wireless communications.

Keywords: Dual band, IEEE 802.11a WLAN, Rectangular Slot, Microstrip Patch Antenna.

I.INTRODUCTION

With the rapid development of wireless communication systems, multiband antenna has been playing a vital role for wireless service requirements, eliminating the need for separate antennas for each application. The wireless local area network (WLAN) is one of the most popular networks for accessing the internet. WLAN has been widely recognized as a viable, costeffective, and highspeed data connectivity solution, enabling user mobility.In WLAN applications, most attention has been focused on the requirement of providing multiband operations, such as covering 2.4, 5.2, and 5.8 GHz bands for the IEEE 802.11 b/astandards. Microstrip patch antenna is preferred for WLAN applications due to its low profile, low weight, low cost and small size. A simple method used in WLAN antennas to cover the three bands is to use one monopole for the lower band and another monopole or a branch structure for the two higher bands [1, 2]. However, due to the required length of monopole for resonating in the lower band, this method leads to a relatively large antenna size. In [3], a pair of symmetrical horizontal strips embedded in a slot on the ground plane was used to excite a dualband resonance. The slot occupied a large area of about 30 x14 mm^2. In [4], a direct-fed planar inverted antenna (PIFA) combined with a parasitic element was proposed for WLAN applications. The PIFA resonated in the fundamental mode at 2.4 GHz and the second-order mode at 5.2 GHz. The parasitic element with one end shorted to ground was used to generate the 5.8GHz band. Although the height had been reduced compared with other PIFA antennas, the antenna was rather high profile and still occupied a larger volume than a planar antenna due to the PIFA structure. Different techniques for WLAN dualband designs are reported in [1-7]. However, these microstrip antennas are not specifically designed for WLAN802.11a dual band. In [8], Deshmukh presented a bandwidth enhancement method of microstrip antenna using quarterwavelength resonant slots. However, at the lower frequencies, the higher crosspolarization level is observed. In [9], a compact dualband rectangular microstrip antenna (RMSA) was realized by two different singleslotted singleband rectangular microstrip antennas with slotted ground plane. However, the limitation found related to the packaging of the antenna is due to the presence of the slot in the ground plane. In [11], dual band monopole antenna was analyzed for WLAN/WiMAX applications. Basic designand description about microstrip antenna was reported in [12–16].Compact and broadband design methods of lowprofile microstrip antennas have been discussed in [17].

In this paper, the design of a dualband microstrip antenna for WLAN IEEE 802.11a band application is realized by embedding a singlerectangular shaped slot in the radiating patch. The proposed antenna covers the 5.2/5.8 GHz WLAN 802.11a operatingband.The proposed configuration was simulated using Advanced Design System (ADS).

II.ANTENNA DESIGN

The configuration of the proposed antenna is shown in Fig. 1. The rectangular patch is etched on a low cost FR4 substrate with a dielectric constant of 4.4 and thickness of 1 mm. A 50Ω micro strip line with width (W_f) of 1.48 mm and length of 5.47mm is used for feeding the antenna. By this configuration we can obtain resonance at 5.2 GHz. Next a rectangular slot is embedded symmetrically on the rectangular patch for dual band operations. The dimension of the slot is 5.8 x 0.3 mm^2. Due to the presence of the slot, a new resonant mode at 5.8 GHz can be easily excitedso as to obtain the desired dualband operation. The entire size of the antenna is only 13.47x17.52x1mm^3.The parameters were adjusted to obtain two wide bandwidths suitable for 5.2/5.8 GHz WLAN operations.

In order to have the desired resonance at more than one frequency generally we can go for multi band techniques. One of the efficient methods of achieving multi band operation is cutting slots in the patch. The length and position of the slots can be changed to obtain the microstrip patch antennas resonating at more than one frequency. In this way we can have the dual or triple band antenna operations.

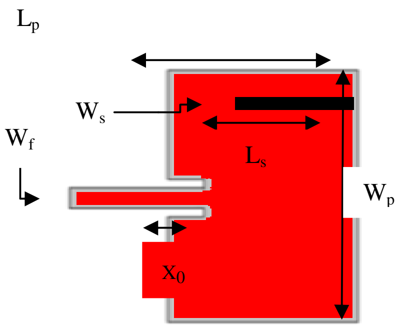


Fig.1. Structure of the proposed antenna

So, inthe designof a dual band antenna, first the parameter value for a single band operationcan be calculatedusing design equations and then a slot cut of appropriate length at appropriate position bemade to obtain dual band operation. Accordingly after getting the desired simulated results for 5.2GHz frequency, the length of a slot made in the patch is adjusted to get it resonated at 5.8GHz frequency too. The optimized values of the antenna dimensions are summarized in Tab. 1.The optimized values of the slot cut are given in Tab. 2. The structure of the desired single band and dual band antennas are shown in Fig. 2 and Fig. 3.

Design equations

The dimensions of the patch along its length have now been extended on each end by a distance ΔL, which is given by empirical equations as follows:

$$\Delta L=0.412h\,(\varepsilon_{reff} + 0.3)\,(W/h + 0.264)/((\varepsilon_{reff} - 0.258)\,(W/h + 0.8)) \quad (1)$$

The effective length of the patch L_{eff} now becomes:

$$L_{eff}=L_p+2\Delta L \quad (2)$$

For a given resonance frequency f_o, the effective length is given by as:

$$L_p=c/\left(2f_o\sqrt{\varepsilon_{reff}}\right) \quad (3)$$

For a rectangular Micro strip patch antenna, the resonance frequency for any TM mode is given as:

$$f_o = c/(2\sqrt{\varepsilon_{reff}})[(m/L)^2+(n/W)^2]^{1/2} \quad (4)$$

Where, m and n are modes along L and W respectively. For efficient radiation, the width W is given as:

$$W_p=c/\left(2f_o\sqrt{(\varepsilon_r+1)/2}\right) \quad (5)$$

Table 1: Antenna dimensions

Parameters	Calculated value (mm)
Patch width, W_p	17.52
Patch length, L_p	13.47

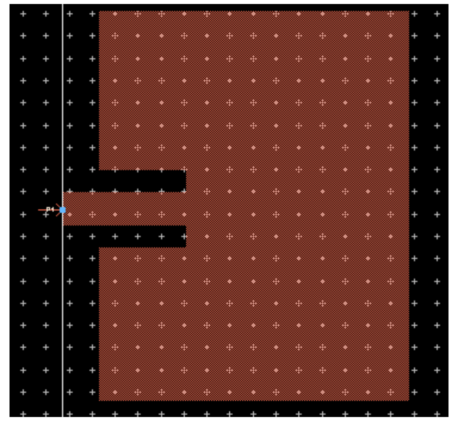


Fig.2. Design of single band rectangular patch antenna

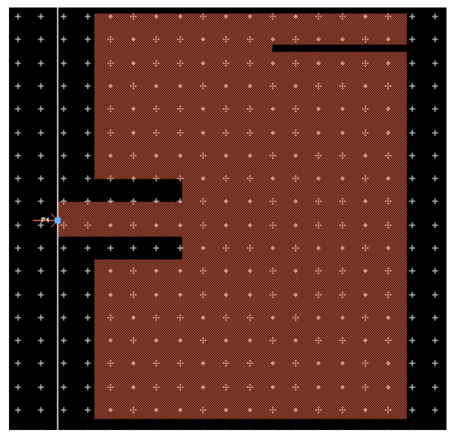


Fig.3. Design of dual band rectangular patch antenna

Table 2: Slot dimensions

Parameters	Calculated value (mm)
Slot width, W_s	0.3
Slot length, L_s	5.8

III.RESULTS AND DISCUSSION

Simulation of the Single Band Rectangular Patch Antenna

The rectangular patch is etched on a lowcost FR4 substrate with a dielectric constant of 4.4 and thickness of 1 mm.A 50Ω microstrip line with width of 1.48 mm and length of 5.47mm is used for feeding the antenna. With this configuration, the simulation was performed and simulated return lossof the antenna is shown in Fig. 4.

Return loss is the power of the reflected signal in a transmission line. It is given in dB.

$$RL \text{ dB} = -20 \log10 \Gamma$$

From the figure 4,it is found that the antenna resonates at 5.2 GHz and the corresponding return loss is -12.778 dB. Now, the entire sizeof the antenna is only 13.47x17.52x1mm^3.

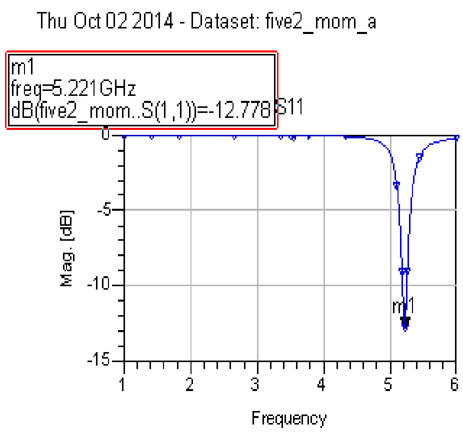


Fig.4. Return Loss Vs. Frequency

Simulation of the Dual Band Rectangular Patch Antenna

In order to explore the dual band operations, a rectangular slot is embedded symmetrically on the rectangular patch. The dimension of the slot is 5.8 x 0.3 mm^2. Due to the presence of the slot, a new resonant mode at 5.8 GHz is easily excited. The length and position of slot was adjusted to obtain two wide bandwidths suitable for 5.2/5.8 GHz WLAN operations. With this configuration, the antenna simulation was again performed and the simulated return loss of the antenna is shown in Fig. 5.

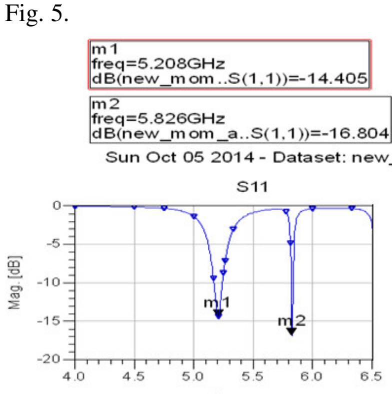


Fig.5. Return Loss Vs. Frequency

From this Fig.5., it is observed that the antenna resonates at 5.2 and 5.8 GHz. It is also found that the impedance matching for the first operation is improved. This is well known from the change of return loss from -12.77 dB to -14 dB. Also -10 dB impedance bandwidth is well for 5.8 GHz operation i.e. its value is found to be -16.8 dB.

Current distributions

In order to clearly see the behavior of the proposed antenna that creates dual band operations in a conventional microstrip antenna, the simulated current distributions at the operating frequencies of 5.2 GHz and 5.8 GHz were investigated by ADS simulation software package, as the results illustrated in Fig. 6 and Fig.7.

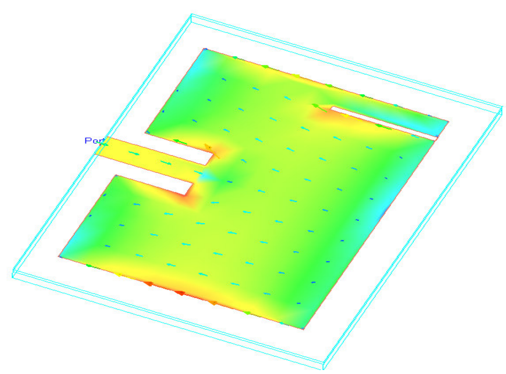


Fig.6. Current distribution of dual band rectangular patch antenna (5.2GHz)

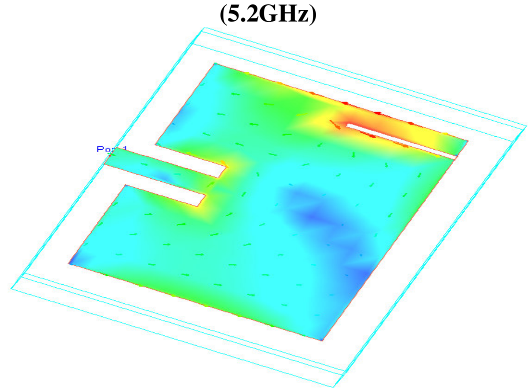
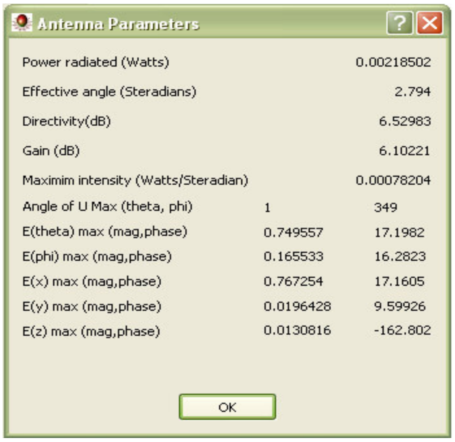


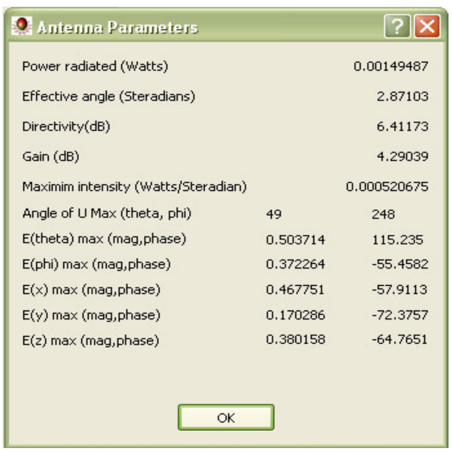
Fig.7. Current distribution of dual band rectangular patch antenna (5.8GHz)

From these figures, it is well known that antenna resonates at the two operating frequencies 5.2/5.8 GHz, which is indicated by the strong current distributions (Red arrows).The corresponding antenna parameters are also shown (Figure 8).



Antenna Parameters		
Power radiated (Watts)		0.00218502
Effective angle (Steradians)		2.794
Directivity(dB)		6.52983
Gain (dB)		6.10221
Maximim intensity (Watts/Steradian)		0.00078204
Angle of U Max (theta, phi)	1	349
E(theta) max (mag,phase)	0.749557	17.1982
E(phi) max (mag,phase)	0.165533	16.2823
E(x) max (mag,phase)	0.767254	17.1605
E(y) max (mag,phase)	0.0196428	9.59926
E(z) max (mag,phase)	0.0130816	-162.802

5.2 GHz



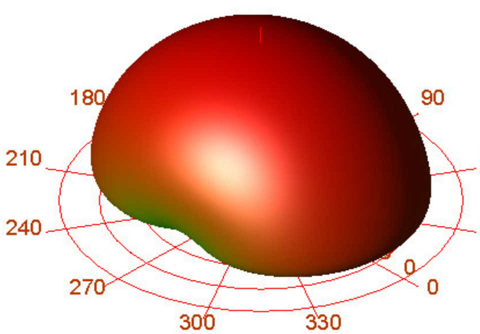
Antenna Parameters		
Power radiated (Watts)		0.00149487
Effective angle (Steradians)		2.87103
Directivity(dB)		6.41173
Gain (dB)		4.29039
Maximim intensity (Watts/Steradian)		0.000520675
Angle of U Max (theta, phi)	49	248
E(theta) max (mag,phase)	0.503714	115.235
E(phi) max (mag,phase)	0.372264	-55.4582
E(x) max (mag,phase)	0.467751	-57.9113
E(y) max (mag,phase)	0.170286	-72.3757
E(z) max (mag,phase)	0.380158	-64.7651

5.8 GHz

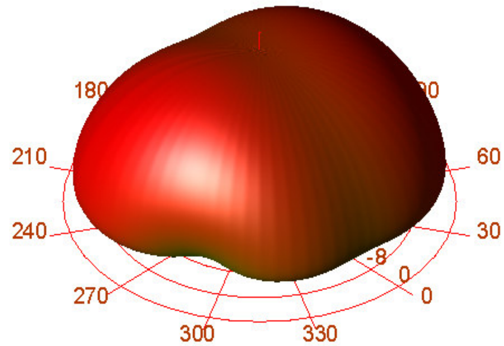
Fig.8. Simulated Antenna Parameters

Radiation patterns

Radiation pattern defines the variation of the power radiated by an antenna. For the proposed dual band antenna the 3D radiation pattern is shown below (Figure 9).



5.2 GHz



5.8 GHz

Fig.9. 3D Radiation Patterns

These radiation patterns confirm that the radiation of the proposed antenna is well above the radiating patch for the dual band operations.

IV CONCLUSION

A microstrip patch antenna for dual band operations was designed and simulated. A dual band operationhas been achieved by etching a single rectangular slot on the radiating plate. The resultant antenna was found to operate in IEEE 802.11a frequency range (5.2/5.8GHz). The entire size of the antenna is only $13.47x17.52x1mm^3$and it will be useful for short range wireless applications.

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