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Design of Microstrip Patch Antenna for Dual Band Operations

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***Abstract*— In this paper a single probe feed microstrip patch antenna with slot is proposed. Dual band operation is achieved through the use of rectangular slot on the patch. The basic antenna is designed to operate at 2.4 GHz WI-Fi application. The antenna designed with HFSS software, demonstrates desirable features for S band applications (2 to 5GHz) and wireless communication application**.

Keywords*— *Frequency reconfigurable microstrip; S-slot antenna

I. INTRODUCTION

As wireless communication systems develop rapidly, reconfigurable antennas have received much attention. This is because they can after a diversity of performance related to operating frequency, polarization and radiation pattern to improve the communication quality and capacity. Nowadays, multifunctional applications are becoming increasingly popular, and such applications are integrating more and more services [1].One possible solution to this demand is to use reconfigurable antenna that tune to different frequency bands. Such an antenna would not cover all bands simultaneously, but provides narrow instantaneous bandwidths that are dynamically selectable at higher efficiency than conventional antennas [2].

Reconfigurability, when used in the context of antennas, is the capacity to change an individual radiator's fundamental operating characteristics through electrical, mechanical, or other means. Thus, under this definition, the traditional phasing of signals between elements in an array to achieve beam forming and beam steering does not make the antenna "reconfigurable" because the antenna's basic operating characteristics remain unchanged in this case. Ideally, reconfigurable antennas should be able to alter their operating frequencies, impedance bandwidths, polarizations, and radiation patterns independently to accommodate changing operating requirements. However, the development of these antennas poses significant challenges to both antenna and system designers. These challenges lie not only in obtaining the desired levels of antenna functionality but also in integrating this functionality into complete systems to arrive at efficient and cost-effective solutions.

In this paper, we propose micro strip patch antenna with rectangular slot for dual band operation. The antenna is designed on FR4 epoxy substrate with dielectric constant of 4.4 and excited by coaxial feeding. The proposed design does not require complicated feeding network. In case of lower frequency, it is very difficult to obtain dual band. But, in the proposed design by using simple rectangular slot antenna, dual band operation is obtained at lower frequency with compactness [3]. Parametric analysis of slot length is made to observe the changes in the dual band operation.

II. ANTENNA DESIGN AND SIMULATION RESULTS

A. Conventional Microstrip Patch Antenna Design

The length and width of the conventional patch antenna can be calculated from the equations (1)-(4) [1]

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

$$\Delta L=0.412h\left[\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)}\right] \quad (2)$$

$$\varepsilon_{reff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[1+12\left(\frac{h}{W}\right)\right]^{-\frac{1}{2}} \quad (3)$$

$$L=\frac{C}{2\sqrt{\varepsilon_{reff}}\left(\frac{1}{f_r}\right)}-2\Delta L \quad (4)$$

Where W is the width of the patch, L is the length of the patch, is the effective dielectric constant of the material, c is the speed of light in a vaccum, f_r is the target frequency, ε_r is the dielectric constant of the substrate, h is the thickness of the substrate and ΔL represents the extension in length called by fringing effect and by considering the dimension of the patch it can be conformably be ignored.

The geometry of the conventional microstrip patch antenna etched on FR4 epoxy substrate with thickness 1.6mm and dielectric constant of 4.4 shown in figure1 (a). The patch dimension is 28.3mm x 36.9mm. The substrate dimension is 86mm x 96mm.

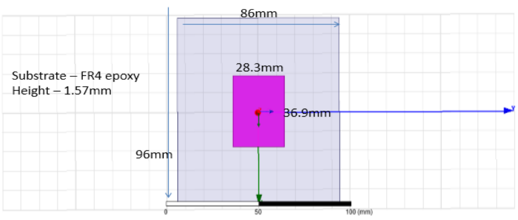


Fig. 1(a) Conventional Microstrip Patch Antenna designed using HFSS for 2.4GHz application

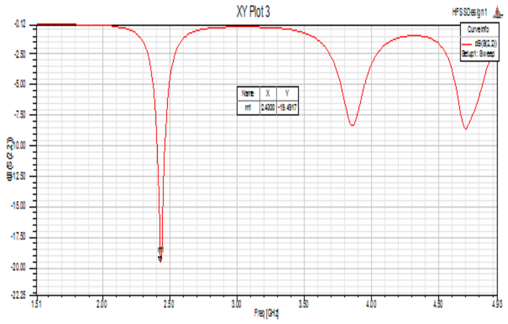


Fig. 1(b) Simulated Return Loss plot of conventional MPA

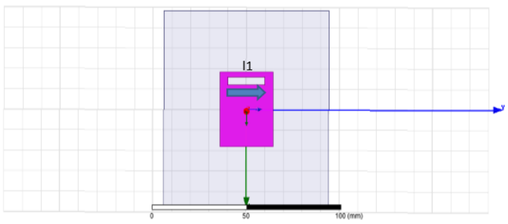
From Fig. (b) We see that the dip is obtained at 2.4GHz which indicates the resonant frequency of the conventional patch antenna. The return loss at this frequency is -19dB. Lower value of return loss indicates maximum input energy is absorbed by the antenna (minimum reflection).

Fig. 1(c) 3D gain plot of MPA simulated using HFSS

From Fig. 1(c) we see that the gain for MPA simulated using HFSS is 3.0dB. This meets the industry standard requirement for Microstrip Patch antenna.

B. Proposed Microstrip Patch Antenna with Slot

The 3D model of the proposed MPA with slot is shown in Fig. 2



The length of the slot is 'l1'.
The width of the slot is 4mm

Fig. 2 3D model of MPA with slot

A rectangular slot is introduced on the patch to obtain the desired dual band operation. The width and length of the antenna is optimized to 4mm x 15mm.

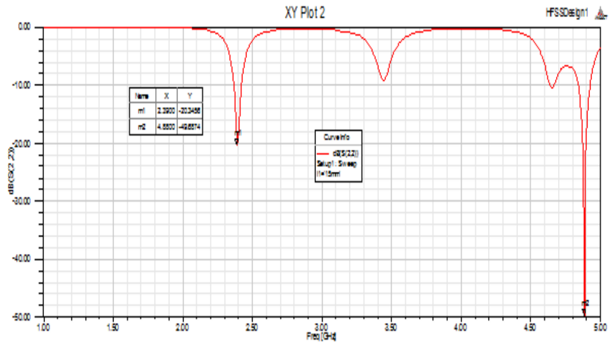


Fig. 3 Return loss plot of MPA with slot simulated using HFSS

From Fig. 3 we see that dual band operation is achieved. The first resonant frequency is 2.2 GHz (same as convention MPA) and the second resonant frequency is 4.55GHz. The return loss in both the band is far less than -10dB as desired.

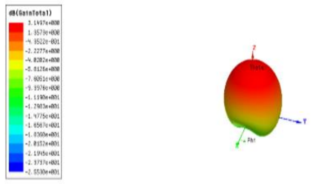


Fig. 4 3D gain plot of MPA with slot simulated using HFSS

From Fig 4 we see that the gain obtained is 3.1dB for 2.4 GHz band which is satisfactory. There is 0.1dB gain enhancement.

C. Parametric Analysis of Microstrip Patch Antenna with Slot

Later, with fixed width of the slot (=2mm) the length of the slot was varied to observe its dependence on the resonant frequency. The results were tabulated as shown in table 1 and its corresponding graph is shown in Fig. 5

Parametric Analysis of length of slot with width =2mm

SL.no	Length of Slot (mm)	Return Loss				Bandwidth		gain	BW%
		B1 (fr) In GHz	B1 (RL) In dB	B2 (fr) In GHz	B2 (RL) In GHz	B1 In GHz	B2 In GHz		
1	15mm	2.39	-20.45	4.88	-36.56	0.04	0.035	3.654	2083333.3
2	16mm	2.39	-19.94	4.81	-25.29	0.07	0.2	2.99	-541666.6
3	17mm	2.4	-19.4	4.7	-20.23	0.04	0.8	3.87	-31666666.7
4	18mm	2.4	-19.4	4.7	-20.23	0.04	0.8	3.85	-31666666.7
5	19mm	2.4	-21.23	4.64	-41	0.03	0.04	3.09	- 4166666.667
6	20	2.4	-21	4.6	-28	0.04	0.15	3.1	- 1270833333.

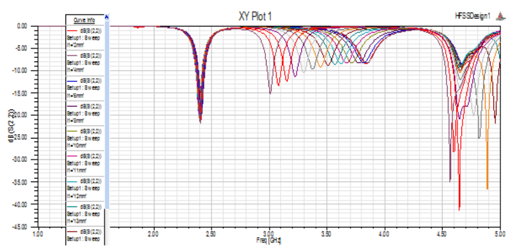


Fig. 5 Parametric Analysis of MPA with slot

From Fig. 5 we see that when the length of the rectangular slot is varied, no change is observed in the first (2.4GHz) band where-as the in the second band, the resonant frequency starts approaching towards 5GHz. Antenna designers can use this knowledge to obtain the suitable frequency band for their applications.

CONCLUSION

In this paper, a microstrip patch antenna with rectangular slot is proposed to obtain the dual band operation in the frequency range 2 to 5GHz. At first, a conventional patch antenna is designed on FR4 epoxy substrate with 1.6mm thickness for Wi-Fi application. Later, a slot is introduced on the conventional patch to obtain the dual band operation in the desired frequency range. Parametric analysis of the slot length is presented to show that the resonant frequency in the second band approaches 5GHz. All the designed antennas have 3dB gain the respective frequencies.

In future, the designed antennas may be fabricated and tested in real time environment.

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