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Design and Analysis of Compact Dual – Band slotted Microstrip Antenna for WLAN Application

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ABSTRACT: A Dual band slotted microstrip patch antenna is designed for IEEE 802.11a WLAN system. It is realized by two single slotted single band microstrip antennas with slotted ground plane. The resulted dual band antenna has impedance bandwidths (dB) of 1.9% and 6.9% at central frequencies 5.33 GHz and 5.93 GHz, with overall gain of 3.82 dBi. The antenna is compact with a dimension of 24 x 16 x 1.6 mm^3 fed with coaxial feeding and prototyped on FR4 substrate. A parametric analysis is done by varying the length and position of the slot so as to operate for WLAN application. The antenna resonant band (5.269-5.371 GHz and 5.742 – 6.156 GHz) meets the IEEE 802.11a standard WLAN band. The Antenna parameters like reflection coefficient, gain, radiation patterns and field distributions are simulated using Finite Element Method (FEM) based High Frequency Structure Simulator (HFSS) tool.

KEYWORDS: WLAN, IEEE 802.11a, Slotted ground, Dual Band, FEM.

I. INTRODUCTION

Emerging applications in wireless communications demand challenging antenna characteristics. Micro strip patch antennas have attracted much interest due to their low profile, light weight, ease of fabrication and compatibility with printed circuits. However, they also have some drawbacks, ranging from narrow bandwidth to low gain. To overcome their inherent limitations of narrow impedance bandwidth many techniques have been proposed. One of the techniques is using Quarter-wavelength resonant slots [1]. Inclusion of open ended rectangular slots increases the impedance bandwidth more compared to E and S [2-4] shaped slots. The WLAN [5-6] Frequency ranges in US are 5.15-5.35 GHz and 5.725 – 5.825 GHz and in Europe are 5.15-5.35 GHz and 5.470 – 5.725 GHz that offers data rate up to 54 Mbps. Different techniques to obtain dual band antenna for WLAN application were reported in papers [7-10]. Compact and broadband low profile microstrip antenna design methods are discussed in [11]. The effect of ground slot on a single slotted antenna is presented in [12].

In this paper, the design of dual band micro strip antenna for IEEE WLAN application is obtained by integrating two single slotted antennas embedded with a rectangular ground slot. The presence of slot in the ground shifted the resonant frequencies so that they are suitable for the required application. The resulted antenna resonates at two frequencies and the separation between the two bands is 371 MHz. The proposed model is designed and analysed using FEM based Electro- magnetic software tool High Frequency Structure Simulator. The detailed explanation of the model is explained in the design section of Antenna.

II. ANTENNA DESIGN

The proposed model is a slotted antenna modified in different stages. Antenna 1 is a reference antenna without any slots. It resonates at a single frequency with more return loss. Antenna 2 consists of an open ended rectangular slot to the right of the patch without any slots in ground. Antenna 3 consists of an open ended rectangular slot to the left of the patch without any slots in ground. These antennas resonate at single frequencies and they are shifted by the insertion of

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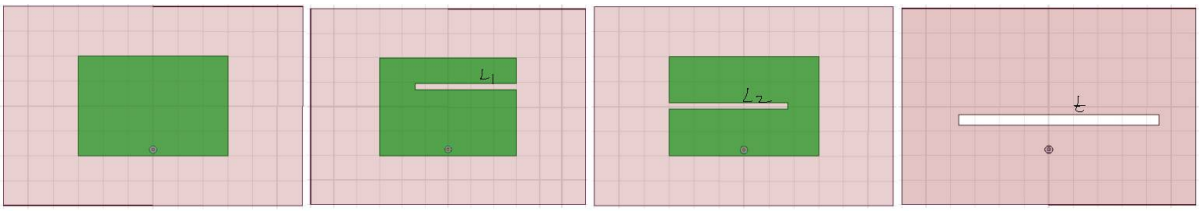
rectangular slot in the ground so that the resulting antennas 4 and 5 can be used individually for WLAN application. Antenna 4 consists of an open ended rectangular slot to the right of the patch with a rectangular slot in the ground. Antenna 5 consists of an open ended rectangular slot to the left of the patch with a rectangular slot in the ground. Finally, Antenna 6 is designed by integrating both antennas 4 and 5 with a ground slot so that the resulting antenna resonates at two frequencies which are useful for WLAN application with improved Return Loss and other factors. The results are discussed below.

The dimensions of the antenna are 24 x 16 x 1.6 mm^3. It is prototyped on FR4 Epoxy substrate of permittivity of 4.4. The model is as shown in Fig 1.



(a) (b) (c) (d)

Fig 1: (a) Antenna 1 (b) Antenna 2 with L1 length slot. (c) Antenna 3 with L2 length slot (d) Slot in the ground with length t and it is back view of Antenna 4 and Antenna 5 with front view same as (b) and (c) respectively.

The final antenna 6 design and the design measurements are shown in Fig 2.

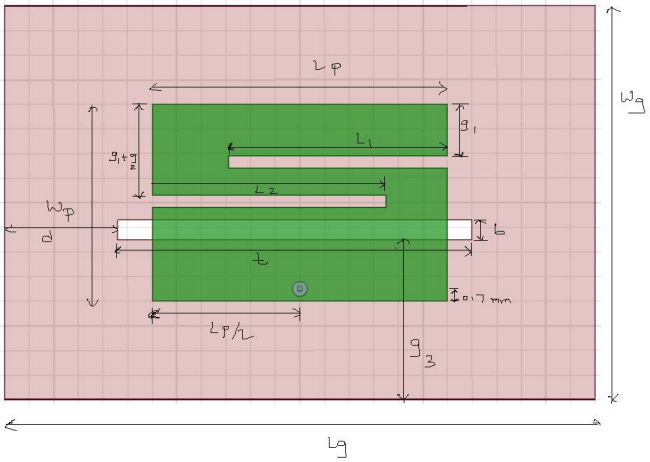


Fig 2: Antenna 6 with two slots integrated in patch and with a ground slot.

The variables Lg and Wg are the ground dimensions. Lp and Wp are the patch dimensions. h represents the height of the antenna. L1 and L2 are the slot lengths of the patch. g1 and g2 are the positions of the slots. t is the length of the ground slot. g3 and d represents the position of the ground slot. b is the thickness of the ground slot. The measurements are shown the in the below Table 1.

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Variable	Dimensions (mm)
Lp	**12**
Wp	**8**
Lg	**24**
Wg	**16**
h	**1.6**
L1	**8.9**
L2	**9.5**
t	**13.4**
b	**0.8**
g1	**2.1**
g2	**1.3**
g3	**6.5**
d	**4.6**

Table 1: Antenna Dimensions

III. RESULTS AND DISCUSSIONS

The characteristic impedance of the coaxial probe is 50 ohms. In order to achieve the impedance matching, the feed point is to be located on the patch such that the impedance is matching. The benchmark to measure the return loss of an antenna is a -10dB line where the frequencies below -10dB line have less return Loss. Fig 3 shows the Return Loss comparison chart of Antenna 1,2,3,4,5. From the figure we can observe that introducing slot in the ground shifted the resonant frequencies to the left to be used for different wireless applications.

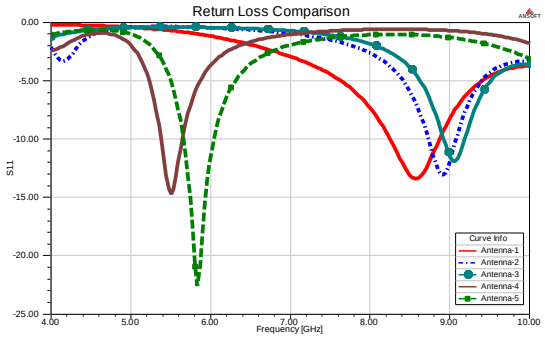

Fig 3: Return loss Vs Frequency of different Antennas 1,2,3,4,5.

A parametric Analysis is done by varying the slot lengths L1 and L2 and positions g1 and g2 of the slots in the patch and the results are shown in figures 4 and 5.

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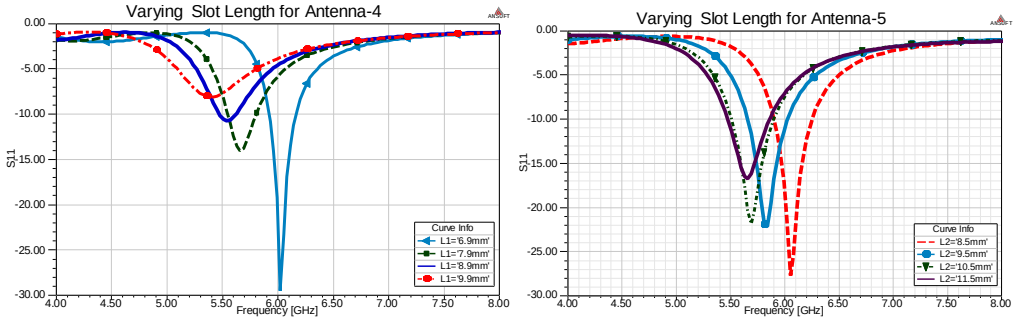

Fig 4: Return Loss vs Frequency varying Slot length L1 and L2.

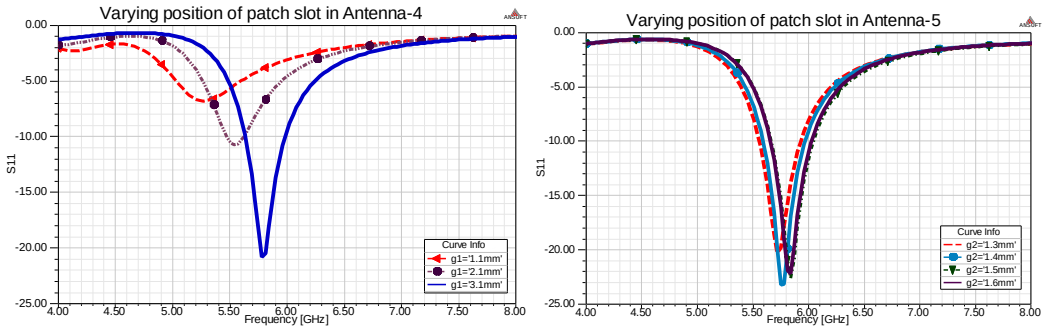

Fig 5: Return Loss vs Frequency varying position (g1 and g2) of slots of length L1 and L2.

From the figures 4 and 5, we observe that for the values L1=8.9mm, L2=9.5mm, g1=2.1mm and g2=1.3mm, the Return Loss is optimum.
The parametric analysis of Ground slot length and position variations are shown in Fig 6

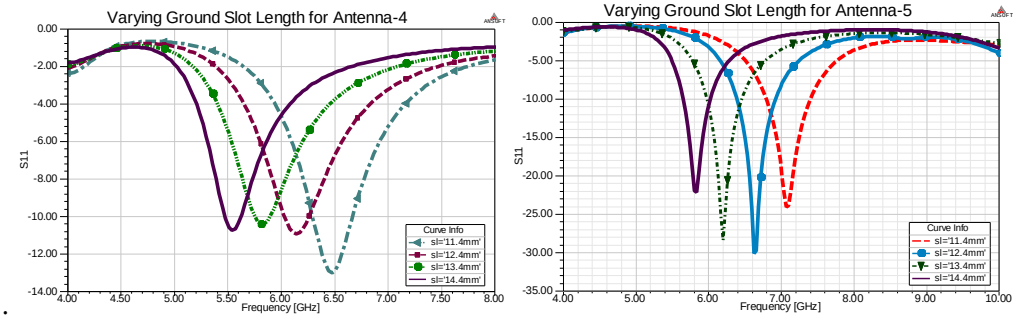

Fig 6: Return Loss vs Frequency by varying Ground slot Length and position.

From the figure 6, the ground slot length is fixed as t=13.4mm since for this slot thickness, the Return Loss is very less compared to remaining slot lengths providing other parameters at optimum values. As per the parametric results, the dimensions of the slot lengths and postions were fixed and final antenna 6 dimensions were given in Table 1. The resulting antenna 6 is a dual band antenna which is an integration of Antenna 4 and Antenna 5 and hence the two single bands clubbed together and obtained a dual band in Antenna 6 which is shown in figure 7. Antenna 6 has two resonant

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frequencies at 5.327 GHz and 5.93 GHz and the corresponding return loss is -25.814 dB and -43.366 dB at the respective resonant frequencies. The Return Loss vs Frequency is shown in Fig 8.

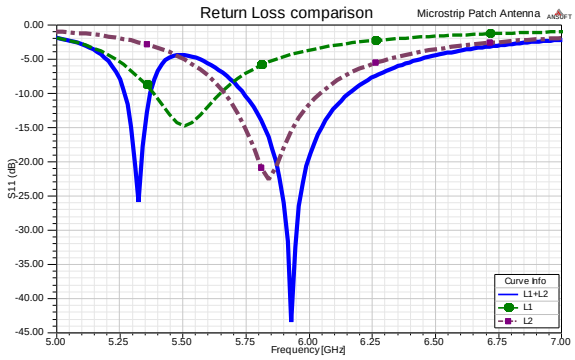

Fig 7: Return Loss vs Frequency of Antenna 4,5,6

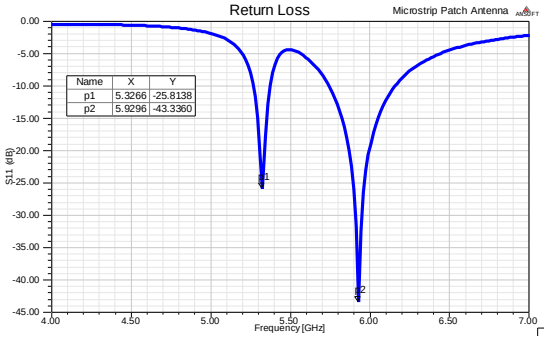

Fig 8: Return Loss vs Frequency of Antenna 6

The total bandwidth of the Antenna 6 for the two resonant bands (5.269 GHz-5.371 GHz) and (5.742 GHz – 6.156 GHz) is 516 MHz. The fractional bandwidths at the resonant frequencies are 1.9% and 6.9% respectively. A peak realized gain of 3.82dB can be observed from the 3D gain plot shown in fig 9.

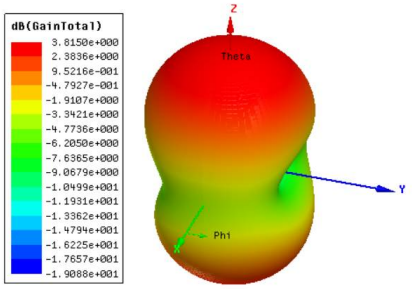

Fig 9: 3D gain of the antenna

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The surface current distributions are shown in fig 10.

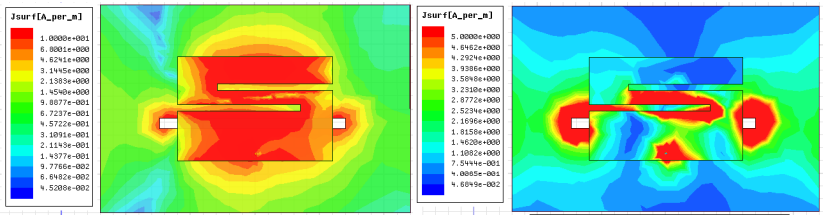
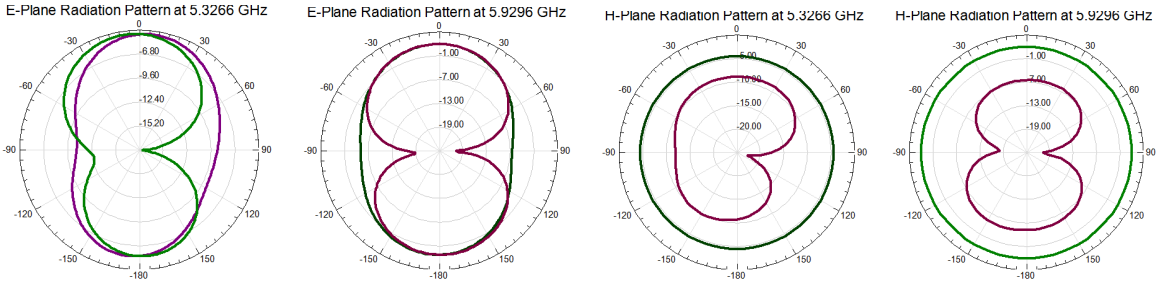


Fig 10: Surface Current distributions at the resonant frequencies of Antenna 6

The Surface Current distribution shows that the current is distributed more on the patch for the resonant frequency 5.327GHz over the other resonant frequency 5.93GHz. The E-Plane and H-Plane Radiation Patterns at the two resonant frequencies of Antenna 6 are shown in Fig 11. The radiation patterns in figure 11 represent a bi directional radiation pattern in E Plane and an omni-directional radiation pattern in Azimuthal plane.



(a) (b) (c) (d)

Fig 11: (a) and (b) are E-Plane radiation patterns and (c) and (d) are H-Plane radiation patterns at 5.23GHz and 5.93 GHz respectively

IV. CONCLUSION

A compact Dual band micro strip antenna is designed and analysed using HFSS and it is useful for IEEE 802.11a WLAN application. Initially, the two single band antennas with same ground slot were designed and then they are combined in order to get a dual band operation. The resulting Antenna resonates at the two bands (5.269 GHz-5.371 GHz) and (5.742 GHz – 6.156 GHz). More deterministic parameters like VSWR, Gain, Radiation Patterns, Current distributions etc. were studied and they are in permissible limit.

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