Investigation of MultiSlot and Stacked Layer on Dual Band Printed Dipole Antenna

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Abstract In this paper, the investigation of multislot and stacked layer on dual band dipole antenna is presented. The effect of the stack on dipole and a slot dipole with a stacked antenna was looked into for different types of slots. Three slots were focused in this paper, which were H-slot, T-slot, and U-slot. All the designs were designed and were simulated using Computer Simulation Technology (CST) software. The investigation was done on the return loss and the radiation patterns of the dipole antennas based on the effect of different types of slots. The simulation results showed that the multislot and stacked layers improved the efficiency and the bandwidth of the basic dipole antenna at 5.8 GHz.

1 Introduction

Recently, both in urban and indoor environments, the wireless communication system has been developed exponentially worldwide. The increasing demands of the usage of wireless communication devices have made the broadband and multi-band antenna designs vital in the system. Hence, in order to enhance the performance

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of the antenna, researchers have applied several methods to overcome a number of identified problems. The microstrip antennas have advantages, such as compact, low in cost, and ease of fabrication [1], whereas the printed dipole with integrated balun [2–5] has omnidirectional features, and it can be used as an element on antenna array architecture. On the other hand, printed dipole with U-slotted arms [6] generate new resonant frequencies at 5.2 GHz, while the features of dual band printed dipole antenna with parasitic elements have been described by [7, 8], and the U-slot stacked patch antenna [1] observes the effect of stacked elements. Besides, the experimental results showed that the stacked or parasitic elements operated with dipole antennas to realize the additional resonance modes.

In this study, the properties of stacked elements of the dipole with various types of slots are discussed based on the performance of antennas. A basic dipole antenna (Design A) that operated at 2.45 GHz frequency band was designed. The dual band frequencies were achieved by adding a slot on the similar conductor plane (top layer) and the stacked layer above the conductor. The additional stacked layer and slot produced two resonant modes. The designed antenna was targeted to operate for WLAN applications based on the IEEE standard, which has the operating frequencies of 2.4–2.4835 GHz (IEEE 802.11b/g), and 5.725–5.825 GHz (IEEE 802.11a).

2 Antenna Design

Figure 1 shows the design structure for dipole antenna. The antenna was modified from the previous work by [2, 3]. The antenna was designed on a FR-4 substrate with a thickness, h, of 1.6 mm and permittivity, εr, of 4.4, and a tangent loss, tanδ, of 0.019. The dimension of the structure was 75.85 × 50 (Wsub x Lsub) mm. The microstrip via-hole balun acted as unbalance to balance transformer between the two printed dipole strips and the coaxial feed line. The length of the dipole arms, L_d, was used to determine the first resonant modes, which were 2.45 GHz. The optimized antenna parameters for WLAN operation are given (in millimetres, mm) as follows: Dipole arms: L_d = 20.4, W_d = 6, g_1 = 3; microstrip balun feed: L_f = 31,

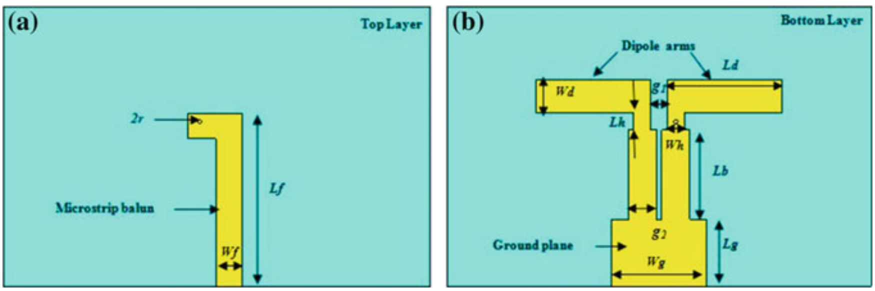

Fig. 1 The geometry of basic dipole antenna Design A: **a** *Top* layer. **b** *Bottom* layer

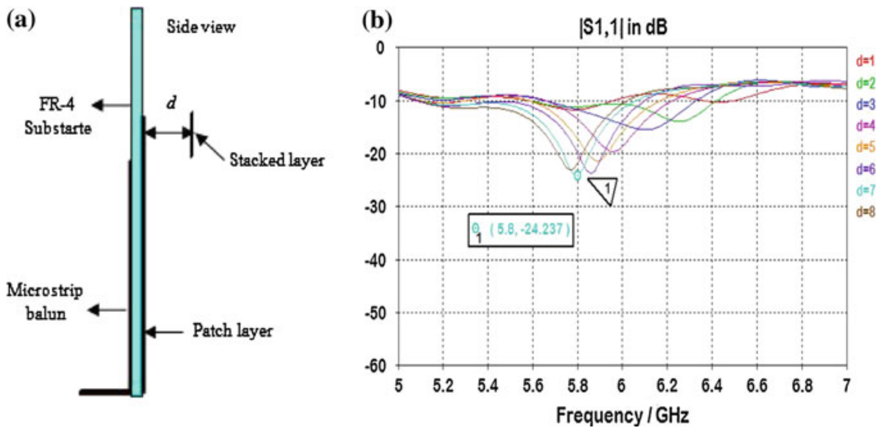

Fig. 2 The structure of stacked layers antenna. **a** Design structure of the stacked layer antenna Designs B, C, and D. **b** The effect of distance, **d**, on return loss

L_b = 16, L_h = 3, W_f = 4.5, W_b = 5, W_h = 3, g_2 = 1; Via hole radius: r = 0.375; and Ground plane: L_g = 12, W_g = 17. Four designs were simulated and compared in this paper, which were a basic dipole antenna (Design A), a radiator dipole arm with stacked layers (Design B), a slot radiator dipole arm with stacked layers (Design C), and a slot radiator and ground with stacked layers (Design D). Figure 2 shows the structure of stacked layer antenna and the effect of distance, d on return loss.

The simulation process had been carried out to investigate the effect of the various slot structures on the performance of the antennas, which was present in Design C. The slot that was investigated had been H-slot, T-slot, and U-slot, which were applied to the dipole arms. The stacked layer was also added to Design C with a d of 7 mm. Figures 3a, b, and c show the design structure of Design C with parameters of H-slot, T-slot, and U-slot using a width slot of 1 mm.

Figures 4a, b, and c show the additional slot on the ground element of dipole arm Design D. This structure was produced to investigate if the additional slot on ground element could affect the performance of the antenna. The parameter of the

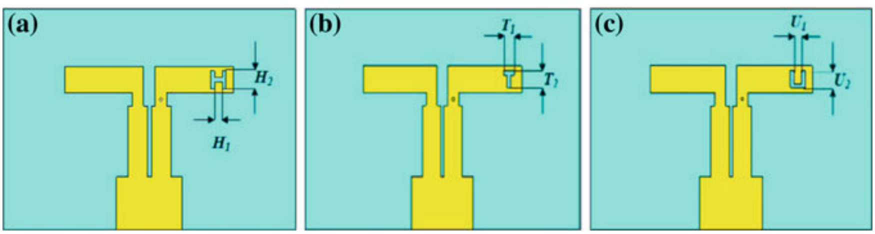

Fig. 3 The parameter of slot on dipole arms (driven): **a** H-slot (H1 = 2 mm, H2 = 4 mm and slot width, w = 1 mm), **b** T-slot (T1 = 3 mm, T2 = 4 mm, slot width, w = 1 mm), and **c** U-slot (U1 = 2 mm, U2 = 4 mm, slot width, w = 1 mm)

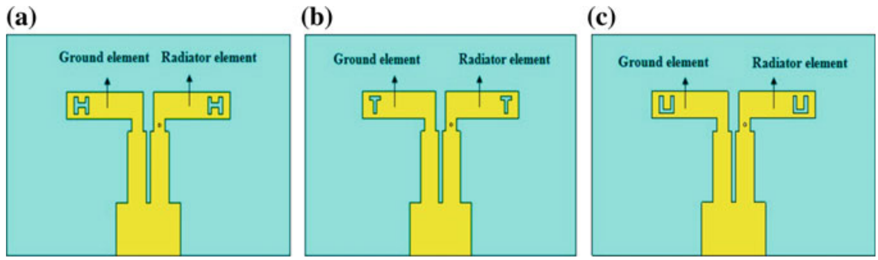

Fig. 4 The parameter structure of slots on dipole arm for radiator and ground elements: **a** H-slot, **b** T-slot, and **c** U-slot

additional slot used on the ground dipole arm had been similar to Design C. The proposed antenna also included stacked layer at radiator and ground elements, is presented. This additional structure was used to increase the efficiency and the directivity of the antenna.

3 Results and Discussion

This section discusses the parametric analysis results for the different slots with additional stacked layer on the printed basic dipole antenna. The parameters of the antenna that had been investigated were return loss, gain, directivity, and radiation pattern. Figures 5, 6, and 7 show the comparison of return loss for various types of designs. The designs that were investigated in this paper were the basic dipole antenna Design A, basic dipole with additional stacked layer Design B, H-slot stacked layer on radiator elements Design C, and H-slot stacked layer at both dipole radiator and ground elements Design D. The results showed that Designs B, C, and D did not affect too much on resonant frequency of 2.45 GHz. However, the significant effect was observed at resonant frequency of 5.8 GHz. Table 1 shows the

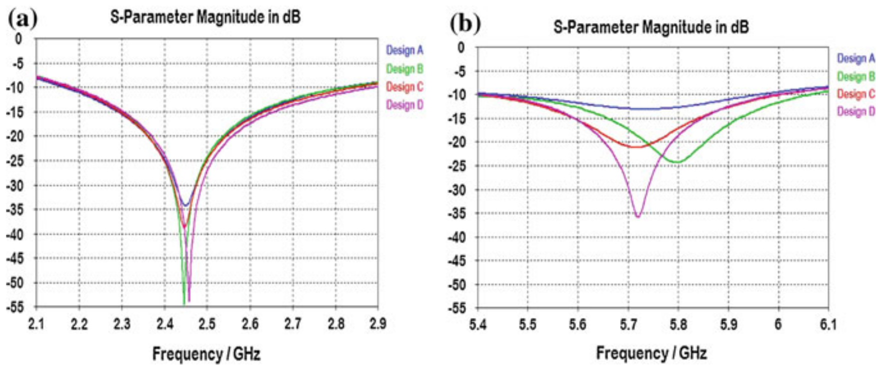

Fig. 5 Return loss for Designs A, B, C, and D, with additional H-slot: **a** 2.45 GHz. **b** 5.8 GHz

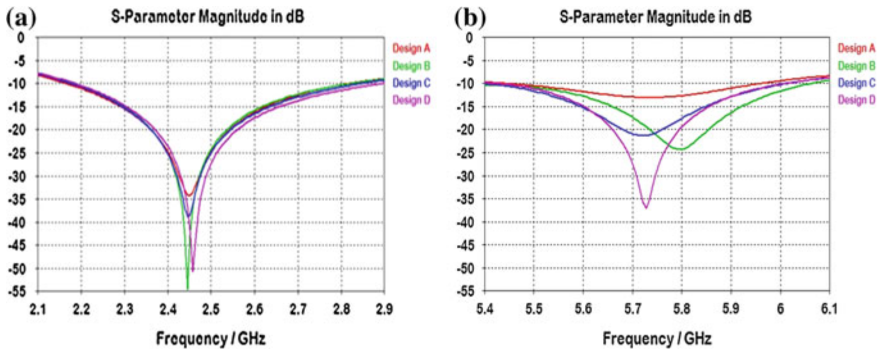

Fig. 6 Return loss for Designs A, B, C, and D, with additional T-slot. **a** 2.45 GHz. **b** 5.8 GHz

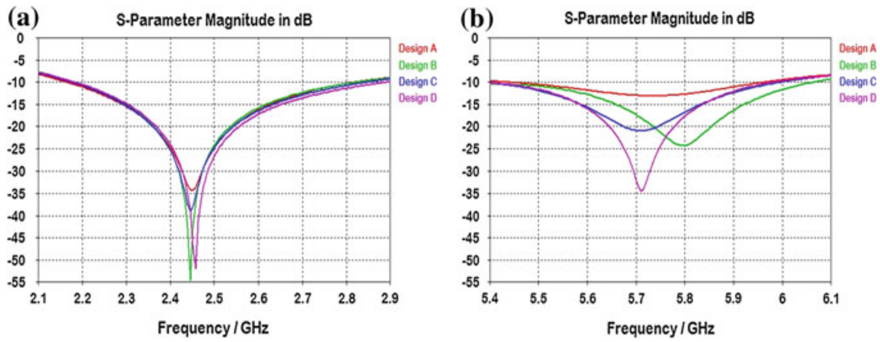

Fig. 7 Return loss for Designs A, B, C, and D, with additional U-slot. **a** 2.45 GHz. **b** 5.8 GHz

Table 1 The return loss and bandwidth for Designs A, B, C, and D at frequencies 2.45 and 5.8 GHz

Parameter	Frequency (GHz)	A	B	C (H-Slot)	D (H-Slot)	C (T-Slot)	D (T-Slot)	C (U-Slot)	D (U-Slot)
Return loss (dB)	2.45	−34.28	−54.68	−34.90	41.62	−38.92	−40.00	−34.92	41.50
	5.8	−12.68	−24.28	−17.14	−18.63	−17.20	−19.48	−16.69	−17.66
Bandwidth (GHz)	2.45	0.66	0.65	0.66	0.72	0.68	0.72	0.67	0.71
	5.8	0.52	0.65	0.62	0.62	0.62	0.62	0.63	0.63

Table 2 The gain and directivity for Designs A, B, C, and D at frequencies 2.45 and 5.8 GHz

Parameter	Frequency (GHz)	A	B	C (H-Slot)	D (H-Slot)	C (T-Slot)	D (T-Slot)	C (U-Slot)	D (U-Slot)
Gain (dB)	2.45	2.642	2.660	2.682	2.772	2.682	2.772	2.783	2.773
	5.8	3.678	4.501	4.2	4.442	4.241	4.562	4.241	4.357
Directivity (dBi)	2.45	3.632	3.624	3.651	3.724	3.650	3.722	3.650	3.772
	5.8	4.941	5.656	5.471	5.552	5.508	5.623	5.432	5.485

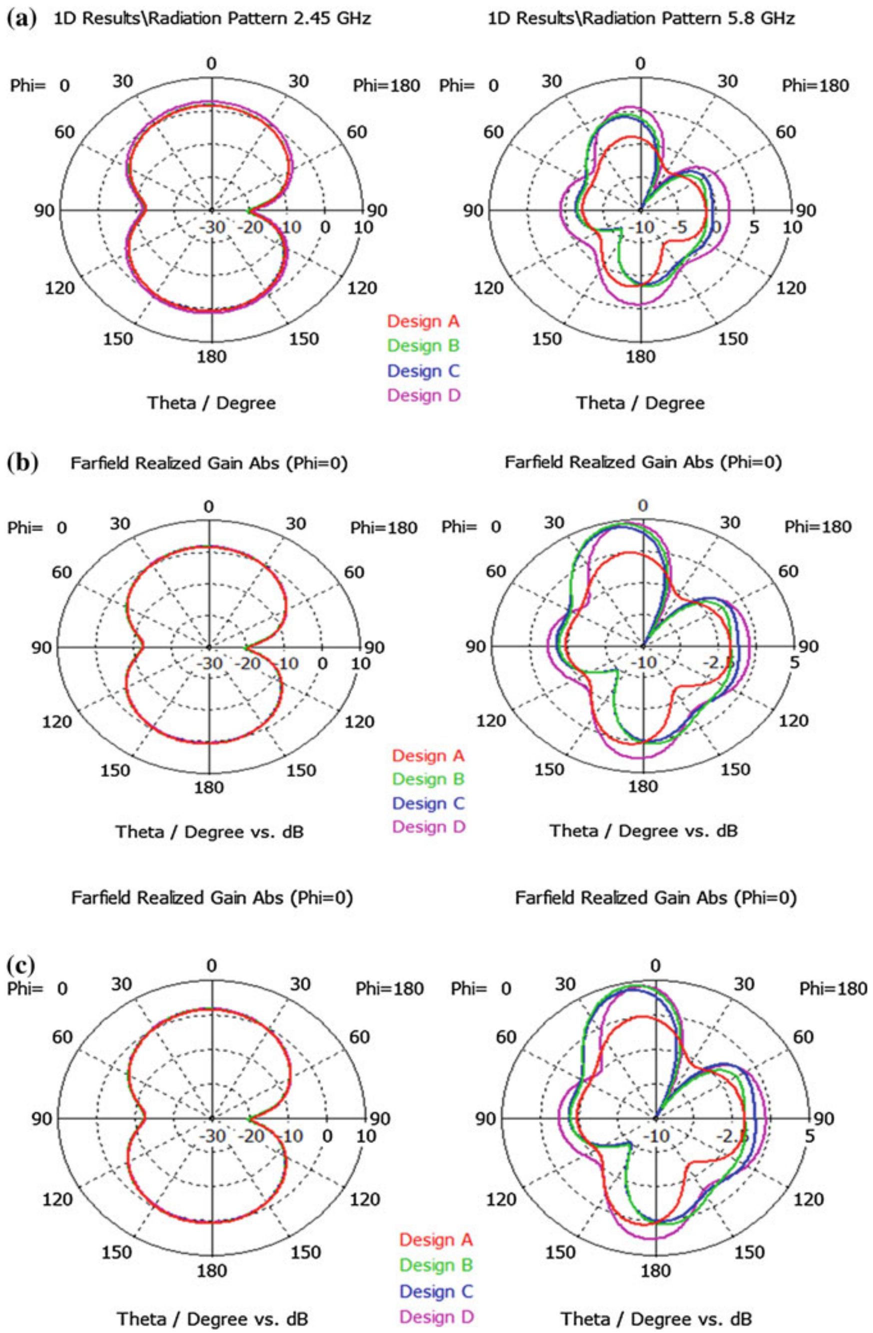

Fig. 8 The simulated radiation pattern of Design A, B, C and D at frequency of 2.45 and 5.8 GHz **a** H-slot, **b** T-slot, **c** U-slot

return loss and bandwidth for Designs A, B, C, and D at frequencies 2.45 and 5.8 GHz, and the return loss for H-slot, T-slot, and U-slot. From the results, the additional slot with stacked had slightly increased the efficiency and the bandwidth of the antenna.

Table 2 shows the gain and directivity of the antennas for Designs A, B, C, and D at frequencies 2.45 and 5.8 GHz. Designs C and D illustrated the gain and the directivity of the antennas with additional H-slot, T-slot, and U-slot. The results showed that when the additional slot with stacked was applied to the basic dipole antenna, the gain and directivity increased to 2.45 GHz. However, different characteristics had been noted at frequency 5.8 GHz. This was because the return loss of the designed antenna had shifted due to the additional slot stacked.

Figure 8 shows the comparison of radiation patterns between Designs A, B, C, and D at frequencies of 2.45 and 5.8 GHz. There was not much difference in the radiation pattern for all the designs at 2.45 GHz. Probably; this had been due to the main radiation that was contributed by the main radiator of the basic dipole. However, there were significant changes or effects of the additional slot and stacked layers on the dipole antenna at the frequency of 5.8 GHz. The radiation pattern of the basic dipole with slot and stacked layer revealed the big half power beam width and the first null beam width.

4 Conclusion

In this paper, a printed dipole with integrated balun and additional H-slot, T-slot, and U-slot was designed. The simulation results showed that the addition of stacked layer produced the dual band frequencies at 2.45 and 5.8 GHz. Hence, this antenna is suitable for the WLAN application. Meanwhile, the slots on the dipole arm increased the bandwidth. Bigger coverage was obtained by using slots on both dipole arms. In future, the fabrication of antenna prototype can be used to validate the presented simulated data and analysis.

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