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A New CPW-Fed C-slot Based Printed Antenna for Dual Band WLAN Applications

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Abstract— The C shaped structures and alike have been widely used in numerous antenna designs for various applications. In this paper, a printed slot antenna has been introduced as a candidate for use in the dual band wireless communication applications. The antenna slot structure is to be composed of two or more C shaped slots with different lengths combined together to form a single slot structure. The antenna has been fed with 50 Ohms CPW, and the slot structure is to be etched on the ground plane. Performance evaluation of the proposed antenna design has been carried out using a method of moments based EM simulator, IE3D. Simulation results show very interesting results. The antenna with two C-slot structure offers a dual band resonant behavior meeting the requirements of the 2.4/5.2 GHz WLAN. The resulting percentage impedance bandwidths of the modeled antenna at the center frequencies of 2.51 GHz and 5.21 GHz are 22.70 (2.29 GHz to 2.86 GHz), and 4.80 (5.11 GHz to 5.36 GHz) respectively. In addition, the antenna with three C-slot structure possesses a dual frequency resonant behavior covering the 2.45/5.8 GHz WLAN applications. The resulting percentage impedance bandwidths at the center frequencies of 2.45 GHz and 5.71 GHz are 11.80 (2.32 GHz to 2.61 GHz), and 7.2 (5.53 GHz to 5.94 GHz) respectively. Parametric study has been carried out to explore the effects of antenna parameters on its performance. Besides the satisfactory radiation characteristics, the simple structure of the proposed antenna makes it an attractive choice for antenna designers.

1. INTRODUCTION

There has been an ever increasing demand for antennas which can operate at different frequencies as a result of the rapid development of the wireless communication systems. An additional challenge; these antennas have to meet the requirements of these systems to be compact and with multi-band behavior.

The C-based structures have, in different ways, attracted antenna designers to construct antennas for various wireless applications [1–7]. These antennas cover a wide spectrum ranging from multiband [1], dual band [2–4], to impedance enhancement of single resonant applications [5–7]. Regarding antennas for dual-band WLAN applications, many variants of C-shaped structure have been reported in the literature [2–4]. A dual inverted C-shaped slot antenna has been proposed in [2] to cover dual band WLAN. In [3], a printed two C-shaped monopole antenna has been presented for 2.4/5.2 GHz WLAN applications. The C-shaped structure has been used as a ground plane of an L-shaped monopole antenna designed for dual band WLAN, as reported in [4]. However, different slot based structures have been proposed to design antennas for dual-band WLAN applications [8–13].

Based on a former work [7], a CPW fed slot antenna has been introduced in this paper, as a candidate for use in dual band WLAN applications. The proposed antenna slot structure is in the form of a C-shape. Antennas with two and three slot structures with different scales have been demonstrated to achieve the task.

2. THE ANTENNA STRUCTURE

The motivation of the proposed antenna slot structure has arisen from the work of Tsai and York [7], where a single and multiple C-slot antenna structures have been proposed as a means to enhance the impedance bandwidth of a CPW fed slot antenna. Instead of using composite slots with similar scale, as in [7], the antenna slot structures, proposed in this paper, are composed of slots with different scales to provide the required multi-resonant behaviour. Figure 1 shows the geometries of two proposed structures; one is with two slots, while the other has three slots.

The dielectric substrate is supposed to be the FR4 with a relative dielectric constant of 4.4 and thickness of 1.6 mm. A 50 Ω CPW is used to feed the slot antenna. The resulting CPW has a width of about 3.0 mm is placed on the centreline of the slot structure (y-axis).

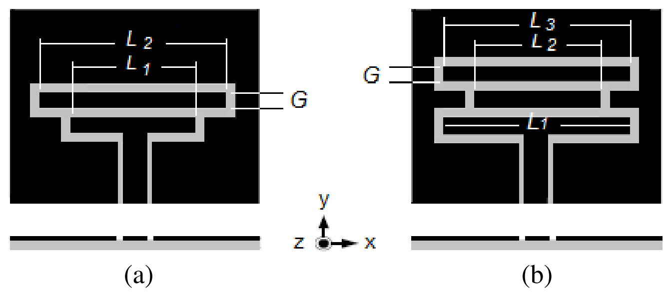

Figure 1: The geometries of the proposed antennas with: (a) two, and (b) three composite C-slot structures.

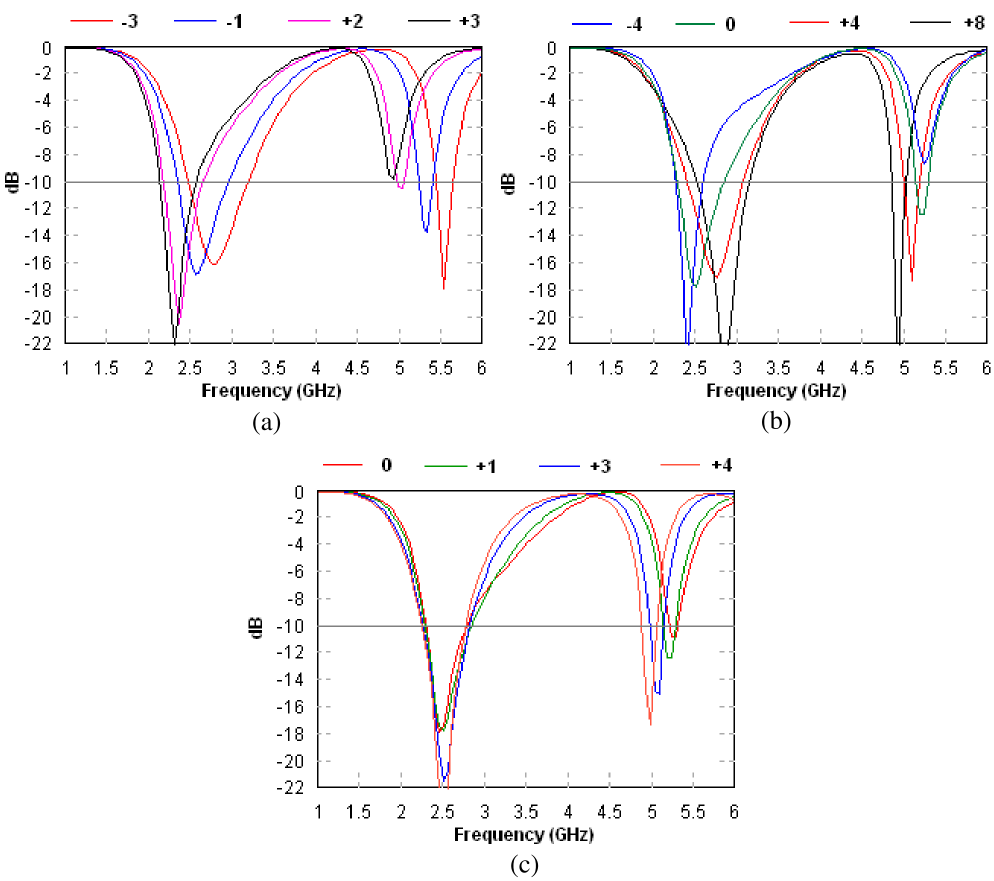

Figure 2: Return loss responses of Ant. I with: (a) L_2, (b) L_1, and (c) G as the parameters.

3. THE ANTENNA DESIGN

Two sets of CPW fed slot antennas, based on the structures depicted in Figures 1(a) and (b), have been designed to resonate a lower frequency of 2.4 GHz. The first set is consist of antennas with two composite C-slots, Figure 1(a), while the other set is with three composite C-slots, Figure 1(b). These antennas have been modeled and analyzed using the method of moments (MoM) based electromagnetic (EM) simulator IE3D [14].

Observing the influence of the various parameters on the antenna performance, it has been found that the dominant factors in the antenna are the slot side lengths L_1 and L_2 of the first antenna structure, L_1, L_2, and L_3, for the second antenna, and the gap width G for both antenna slot structures. In this work, the gap width has been kept the same, $G = G_1 = G_2$, for the antenna geometry depicted in Figure 1(a), and $G = G_1 = G_2 = G_3$, for the proposed antenna shown in Figure 1(b). The slot width, T, has been taken equal to G. Initial antenna designs, based on the structures depicted in Figures 1(a) and (b), have been modeled for such a task. These antennas have been referred to as Ant. I, and Ant. II respectively, and they will be used as references in

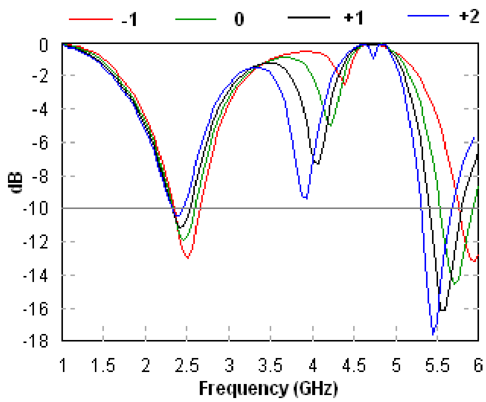

Figure 3: Return loss responses of Ant. II with the gap width G as the parameters.

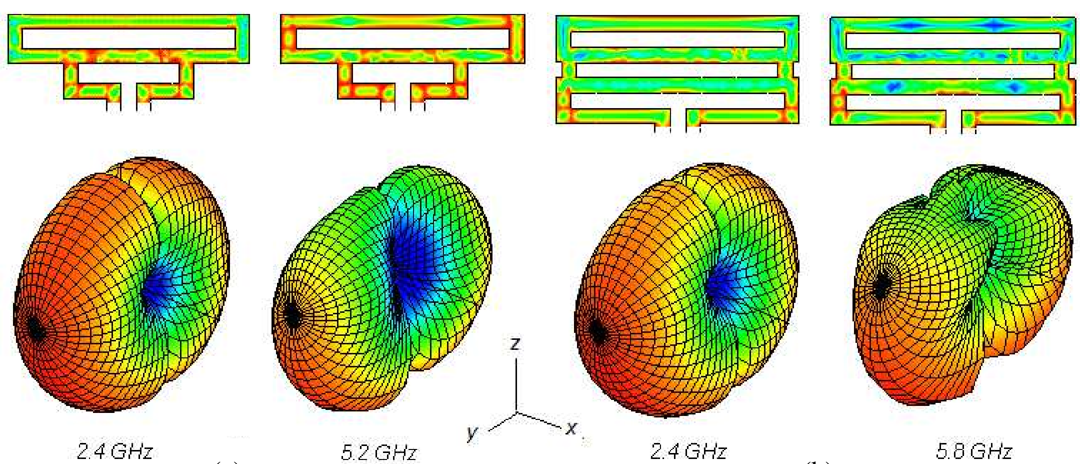

Figure 4: Simulated surface current distributions and the 3D electric field radiation patterns at the corresponding resonances for: (a) Ant. I, and (b) Ant. II.

the related parametric studies to be performed later. Table 1 summarizes the dimensions of these antennas when resonating at 2.4 GHz.

4. PERFORMANCE EVALUATION

A slot antenna with structure depicted in Figure 1(a) has been designed, using the said substrate, to resonate at lower frequency of 2.4 GHz. With these parameters, the antenna exhibits a dual band response, centered near the 2.4 and 5.2 GHz WLAN bands. A parametric study has been carried out to demonstrate the effects of various antenna parameters on its performance, as shown in Figure 2, where the values of L_1, L_2, and Ghave been varied, in mm, with respect to those presented in Table 1, for Ant. I. Figure 2(a) demonstrates the effects of varying the slot length L_2 on the antenna return loss response. Increasing this length causes both the lower and the upper resonant frequencies to be decreased, while approximately maintaining the same frequency ratio f_{0U}/f_{0L}. However, the lower resonant bandwidth is significantly increased with the larger values of L_2, while the upper resonant bandwidth is almost kept unchanged.

On other hand, the variation of the slot length L_1 has an interesting impact on the antenna return loss response, as shown in Figure 2(b). The increase of this length makes the lower and the upper resonant frequencies approaching each other; if the lower frequency is increased the upper frequency will be decreased, and vice versa. This supports the findings reported in [7] where single resonance has been excited, when this length has been increased such that it equals L_2. In this case, the proposed antenna offers different ratios of f_{0U}/f_{0L}, making it suitable for use in many dual band communication applications. The effect of varying the gap width G is shown in Figure 2(c). The lower resonant frequency has almost not affected, while the upper resonant decreases as G has been increased. For a value of $G = 3.6$ mm, the resulting percentage impedance bandwidths of the modeled antenna at the center frequencies of 2.51 GHz and 5.21 GHz are 22.70 (2.29 GHz to

Table 1: Summary of Ant. I and Ant. II dimensions, in mm, as depicted in Figures 1(a) and 1(b).

Ant. I	L_1	L_2	T	$G = G_1 = G_2$	
	20.88	40.82	2.57	2.57	
Ant. II	L_1	L_2	L_3	T	$G = G_1 = G_2 = G_3$
	43.60	41.20	43.60	2.90	2.90

2.86 GHz), and 4.80 (5.11 GHz to 5.36 GHz) respectively.

Due to the limited space, similar parametric study of Ant. II, depicted in Table 1, cannot be provided here. Instead, only the effect of varying the slot gap width G on the antenna return loss has been presented in Figure 3. Many observations can be extracted here. In comparison with Ant. I, Ant. II offers triple band response; with slight modification this might fit triple band WiMAX impedance bandwidth requirements. However, the lower and the upper resonant frequencies and the corresponding bandwidths fit the 2.4/5.8 GHz WLAN bands. The variations of G slightly affect the position of the lower resonant frequency, but the corresponding bandwidths are noticeably increased with the decrement of G, providing an interesting tuning range. For a value of $G = 2.9$ mm, the resulting percentage impedance bandwidths of the modeled antenna at the center frequencies of 2.45 GHz and 5.71 GHz are 11.80 (2.32 GHz to 2.61 GHz), and 7.2 (5.53 GHz to 5.94 GHz) respectively.

Figure 4 summarizes the simulated surface current density on the slot structures of the two antennas at the related resonances together with the corresponding 3D radiation patterns. The resulting values of the antenna gains for the lower and the upper bands are 1.92 and 3.12 dB, for Ant. I and 1.78 and 3.49 dB, for Ant. II respectively.

5. CONCLUSION

In this paper, CPW fed slot antennas with two and three C-slot structures have been presented as candidate for use in dual band WLAN applications. The proposed antennas have been analyzed using a method of moments based EM simulator, IE3D. The conducted parametric studies show that antenna with two C-slot structure fits the 2.4/5.2 GHz WLAN bands, while the antenna with three C-slot structure successfully meet the requirements of 2.4/2.8 GHz WLAN. In addition, this antenna offers triple band resonant behavior; with careful tuning it can meet the triple band WiMAX applications. Furthermore, both antennas possess dual band and triple band behaviors with different resonant frequency ratios; making them suitable for use in a wide variety of dual band and triple band wireless applications. It is hopeful that, the simple structure of the presented antennas besides the degrees of freedom, their corresponding designs offer, will make the proposed antennas an attractive choice for the antenna designers.

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