A New Dual Band E-shaped Slot Antenna Design for Wireless Applications

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Abstract — An E-shaped printed slot antenna is presented as a candidate to cover dualband operation over the entire wireless local area network (WLAN) frequency bands of 2.4–2.5 GHz and 4.9–5.8 GHz. The E-shaped slot structure has been etched in the ground plane, and the 50 microstrip line feed is etched on the reverse side of the substrate. An additional trapezoidal slot has been etched attached to the slot structure on the feeding side to facilitate tuning and the dual-band operation. The antenna structure has been modeled and its performance has been evaluated using a method of moment based electromagnetic simulator, IE3D from Zeland Software Inc. Simulation results show that, the proposed antenna offers good return loss response (for $S_{11}$ less than $-10 \text{ dB}$) at the two bands. The ratio of the two resonating frequencies $f_{02}/f_{01}$ could be varied in a considerable range, without changing the antenna external dimensions, making the antenna suitable for other dual band wireless applications.

1. INTRODUCTION

The application of the E-shaped structure in patch antenna design has been first presented in [1]; in an attempt to overcome the narrow band and the large size of the conventional microstrip patch antennas. Since then, this structure had attracted antenna designers in their efforts to produce antennas with reduced size and broadband performance for different applications. The conventional E-shaped patch antenna has been used to design wideband antennas [2–5]. Various E-shaped patch antennas with tapered, corrugated, and trapezoidal slots have been reported in the literature [6–8]. Many variants of the E-shaped patch structure have been proposed to produce reduced size and wide band antennas [9–12]. Patch antennas with half E-shaped and folded E-shaped structures have been also reported [9, 10, 13–15]. Moreover, the E-shaped structures have been used together with other slot structures to produce antennas with enhanced bandwidths [15–17]. For dual band antenna applications, E-shaped patch structures have been successfully verified as reported in [17, 18].

As a slot, the E-shaped structure has drawn less attention from antenna designers; to name a few [19, 20]. In [19], the E-shaped slot structure has been applied to build a complementary part of an ultrawideband (UWB) antenna to produce the 5 GHz/6 GHz band-notch. In the other work [20], two printed wide-slot antennas constituting of both E-shaped patch and E-shaped slot with rounded corners and fed by CPW and microstrip line have been presented. The presented antennas have been found to possess fractional bandwidths of about 146%.

In this paper, a printed microstrip slot antenna has been presented as a candidate for use in dual-band wireless applications. The slot structure is composed of a main E-shaped part and a small trapezoidal part for tuning purposes.

2. THE ANTENNA STRUCTURE

The geometry of the proposed E-shaped slot antenna structure is shown in Figure 1(a). The slot has been constructed, in the form of E-shape, on the ground plane side of a dielectric substrate. In order to achieve broadband operation, a small trapezoidal slot structure has been etched in the same plane and placed on the feed side of the rectangular E-shaped slot. The dielectric substrate is supposed to be the FR4 with a relative dielectric constant of 4.4 and thickness of 1.6 mm. For design convenience, the proposed antenna is fed by a 50\( \Omega \) microstrip line printed on the reverse side of the substrate. The microstrip line, with a width of 3.0 mm is placed on the centreline of the combined slot structure (x-axis). Figure 1(b) shows the antenna layout with respect to coordinate system.

3. ANTENNA DESIGN

The E-shaped printed slot antenna structure, depicted in Figure 1, has been modeled using the commercially available method of moments based EM simulator, IE3D, from Zeland Software Inc. [21]. The first design step is to make the modelled antenna resonating such that the lower resonant band
is located at 2.45 GHz. This design goal has been reached by suitable rescaling of the whole structure, varying the trapezoid dimensions, \( w_t \) and \( L_t \), and varying the E-shape parameters, \( w_v \) and \( w_h \). At this step, the proposed antenna has the following dimensions. The E-shaped slot dimensions are as follows: \( L_h = 15.52 \, \text{mm} \), \( L_v = 23.38 \, \text{mm} \), \( w_h = 4.12 \, \text{mm} \), and \( w_v = 7.10 \, \text{mm} \). The trapezoidal slot dimensions are: the central length, \( L_t = 5.4 \, \text{mm} \) the larger width, \( w_t = 4.31 \, \text{mm} \), and smaller width is equal to 3.00 mm, which is the same as that of the microstrip line. A parametric study has been carried out to demonstrate the effect of the slot internal dimensions, \( w_v \) and \( w_h \) on the antenna performance, such that the slot external dimensions are being held constant.

4. PERFORMANCE EVALUATION

Observing the influence of the various parameters on the dual band resonant behaviour of the modelled antenna, it has been found that the dominant factors in the antenna structure are the E-shaped slot parameters \( w_h \) and \( w_v \), besides the slot external dimensions.

Figure 2 shows that the return loss response of the proposed antenna is highly affected by the variation of the value of \( w_h \) with constant value of \( w_v = 7.0 \, \text{mm} \). As the value of \( w_h \) has been increased, the antenna dual band behaviour is still maintained. However, the lower resonant frequency has been influenced more than the higher frequency because of the effect of change of \( w_h \).

Variation of \( w_v \) has a little impact on both the lower and the upper resonant frequencies, as Figure 3 implies. Again the lower resonant frequency is relatively more affected than the higher one. Figure 4 shows the simulated the electric field radiation patterns \( E_\theta \), of the proposed E-shaped

![Figure 1](image1.png)

Figure 1: (a) The proposed antenna structure, and (b) its layout with respect to the coordinate system.

![Figure 2](image2.png)

Figure 2: Simulated return loss responses of the proposed antenna for different values of \( w_v = 7.0 \, \text{mm} \) with \( w_h \) as a parameter.

![Figure 3](image3.png)

Figure 3: Simulated return loss responses of the proposed antenna for different values of \( w_h = 4.12 \, \text{mm} \) with \( w_v \) as a parameter.
Figure 4: Simulated electric field radiation patterns, \( E_\theta \), of the proposed E-shaped slot antenna for \( \phi = 0^\circ \) and \( \phi = 90^\circ \) at, (a) 2.45 GHz, and (b) 5.8 GHz. The antenna is printed on an FR-4 substrate. Other parameters are \( w_h = 4.12 \) mm and \( w_v = 7.0 \) mm.

slot antenna for \( \phi = 0^\circ \) and \( \phi = 90^\circ \) at: (a) 2.45 GHz, and (b) 5.8 GHz. The modeled antenna is with slot parameters of \( w_h = 4.12 \) mm and \( w_v = 7.0 \) mm.

5. CONCLUSIONS

A combined E-shaped microstrip printed slot antenna is presented in this paper, as a candidate for use for dual band wireless applications. The antenna has been modeled and its performance has been analyzed using a method of moment based software, IE3D. The proposed antenna shows an interesting dual band resonant behavior with a wide range of the two resonant frequency ratio without changing the external dimensions of the combined slot structure; providing the antenna designer with more degrees of freedom.

REFERENCES


