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CPW-Fed Bow-Tie Slot Antenna with Parasitic Slot Pair for Dual-Frequency Operation

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1. Introduction

Coplanar waveguide (CPW)-fed slot ring and slot loop antennas with coupled microstrip patches have been studied for dual-frequency operation extensively [1]-[4]. These antennas are composed of either a slot ring or a slot loop fed by the CPW with an additional patch printed on the other side of the substrate. Since the slot ring or the slot loop itself acts as a radiator and the back-side patch acts as another, dual-band characteristics can thus be obtained. However, in these antennas, the tuning range of the frequency ratio of the upper and lower operating frequencies is limited and the slot rings and slot loops inherently possess high cross-polarized radiation components. To make improvements, we study in this paper a CPW-fed bow-tie slot antenna with a pair of parasitic slots. The bow-tie slot is not only a radiator but also a driven element to couple power to the parasitic slots, which are also radiators responsible for another frequency. The bandwidth of the upper band and the tuning range of the frequency ratio of the upper and lower operating frequencies are wider and the cross-polarization levels are much lower than those of the designs proposed in [2]-[4]. In addition, the proposed antenna is uni-planar, which needs only one layer of conductor instead of two. Details of the antenna design and simulated and measured results are presented and discussed.

2. Antenna Structure and Design

The configuration of the proposed CPW-fed bow-tie slot antenna with a pair of parasitic slots is shown in Fig. 1. This antenna is formed by placing a pair of parasitic slots, each with length of $2L_1+L_2$, next to the two ends of the CPW-fed bow-tie slot, which has half-length L and height W. In order to produce dual-frequency characteristics, L and $2L_1+L_2$ are chosen approximately equal to a half guided-wavelength at the slot resonance and a guided-wavelength at the slotline resonance, respectively, which correspond to the upper and lower resonant frequencies of the antenna, respectively. The optimum design of the CPW-fed bow-tie slot can be found in [5] and will not be discussed here. The inclined slot sections L_1 contribute to the antenna gain in the lower frequency band but not the vertical meandered slot sections L_2, since the equivalent magnetic currents flowing in the upper and lower halves of L_2 are anti-symmetric such that they cancel out each other in the far field. The inclination angle α between L_1 and the x-axis determines the antenna gain in the lower frequency band. Larger α lowers the antenna gain since less equivalent magnetic current component in the x-direction causes less effective radiation in the far field. It should be mentioned that, by properly choosing the slot widths of L_1 and L_2 and the width w between the bow-tie slot end and the parasitic slot, the input matching condition at the design frequency could be improved. To facilitate the investigation in the next section, we fix the half-length of the bow-tie slot L and the length of the inclined slot section L_1 and vary only the length of the meandered slot section L_2 to lengthen the resonant path of the lower resonant frequency. Thus, a fixed upper resonant frequency and a series of lower resonant frequencies could be observed.

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3. Simulation and Measurement Results

A prototype antenna is implemented and tested first. This antenna is fabricated on an FR-4 substrate with dielectric constant $\varepsilon_r = 4.3$ and thickness $h = 1.6$ mm. The widths of the strip and slot of the 50 Ω CPW feedline, S and G, are determined to be 3.0 and 0.3 mm, respectively. The length of the inclined slot section L_1 is determined to be 11.5 mm and the inclination angle α is chosen to be 38°. In addition, the vertical meandered slot section L_2 is chosen to be 27.5 mm such that the total length of the parasitic slot $2L_1+L_2$ corresponds to a lower resonant frequency of about 3 GHz. The other geometric parameters in this design are listed as follows: $L = 18$ mm, $W = 24$ mm, $w = 1.2$ mm, and the parasitic slot widths of the inclined and vertical meandered slot sections are 2 and 1 mm, respectively. The simulated and measured input return losses of this antenna are depicted in Fig. 2, and they show excellent agreement between them. All simulations in this work are carried out by means of *Ansoft* Ensemble 8.0. The measured impedance bandwidth (return loss > 10 dB) of the lower frequency band of the prototype antenna is 3% (2.98-3.07 GHz), while that of the upper band is 30.9% (4.93-6.73 GHz). The E- and H-plane patterns measured at the two resonant frequencies, 3.0 and 5.7 GHz, are shown in Figs. 3(a)-(d). The radiation patterns at the two resonant frequencies are nearly the same and both are broadside and bidirectional. The cross-polarization levels remain satisfactory around the broadside directions in both principle planes. The peak antenna gains measured at the lower and upper resonant frequencies are 5.5 and 3.1 dBi, respectively. To find the tuning range of the frequency ratio of the two resonant frequencies, a series of prototype antennas with various L_2 (27.5, 51.5, 59.5 and 111.8 mm) are designed and compared with the former one ($L_2 = 27.5$ mm). The measured input return losses plotted in Fig. 4 demonstrate a wide tuning range of the two resonant frequencies of the proposed design. The obtained frequency ratios are wide and lie in between 1.6 and 3.0.

4. Conclusion

A CPW-fed bow-tie slot antenna with a parasitic slot pair has been presented for dual frequency operation. By varying the lengths of the parasitic slots and the bow-tie slot, two operating frequency bands can be separately obtained. The tuning range of the frequency ratio of the two resonant frequencies is considerably wide and between 1.6 and 3.0. The broadside and bidirectional radiation patterns remain almost the same in both operating frequency bands. In addition to the dual-frequency characteristics, the uni-planar and simple structure make the proposed antenna ease of design and mass production. This antenna is suitable for use in the IEEE 802.11a/b/g combo systems and other WLAN applications.

Acknowledgements

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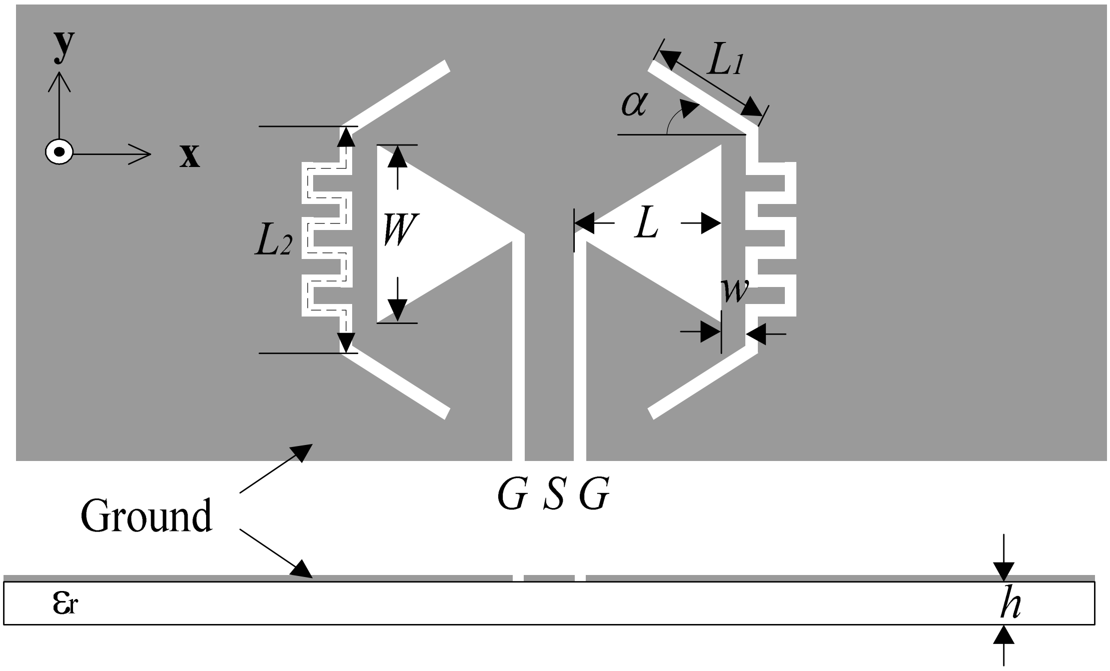


Fig. 1 Geometry of CPW-fed bow-tie slot antenna with a parasitic slot pair.

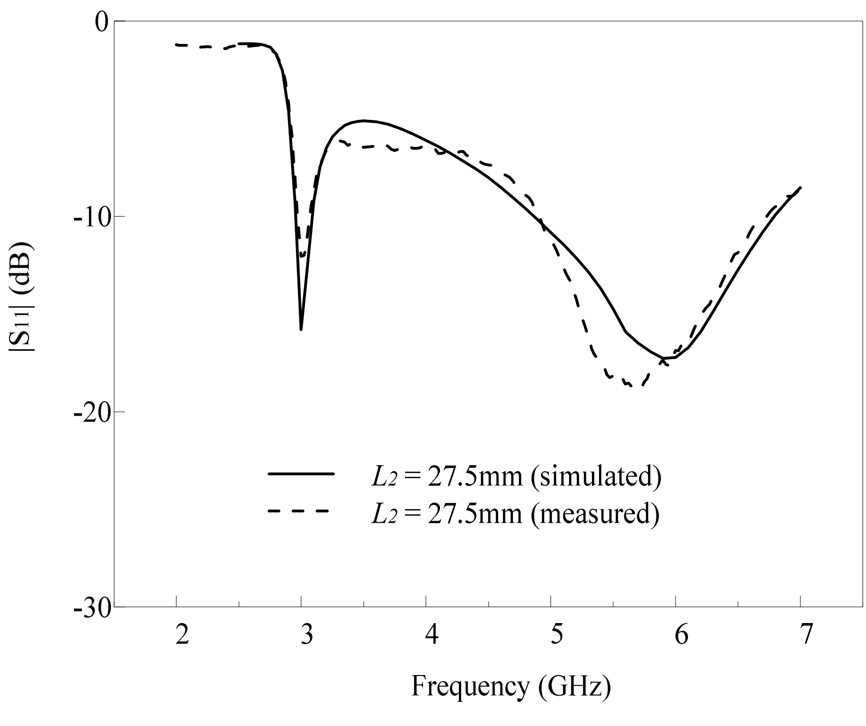
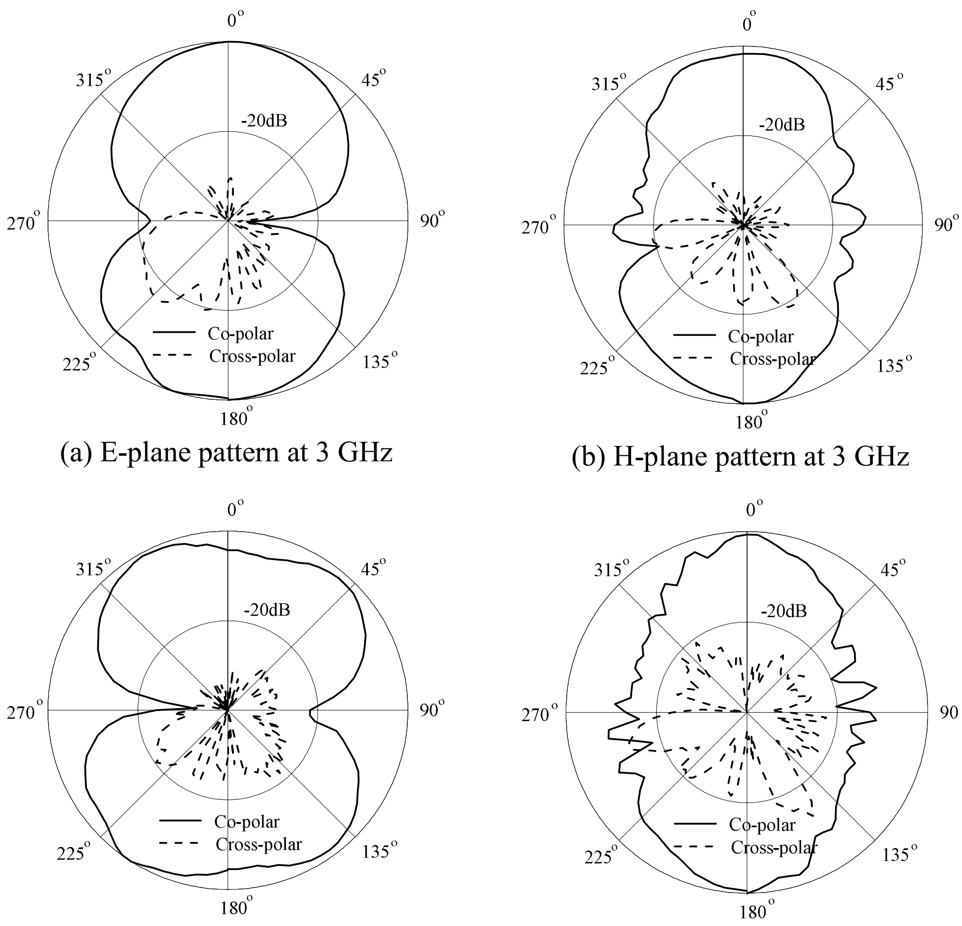


Fig. 2 Simulated and measured input return losses of the prototype antenna.



(a) E-plane pattern at 3 GHz (b) H-plane pattern at 3 GHz

(c) E-plane pattern at 5.7 GHz (d) H-plane pattern at 5.7 GHz

Fig. 3 Measured radiation patterns of the prototype antenna with L_2 = 27.5 mm.

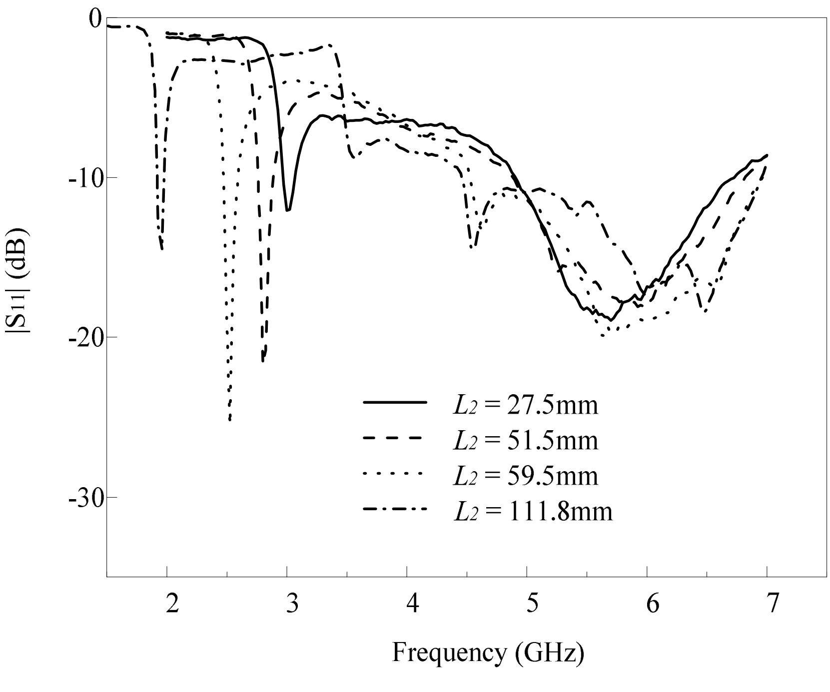


Fig. 4 Measured input return losses of the prototype antennas with various L_2.