Dual-Band Slot Dipole Antenna Fed by a Coplanar Waveguide

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A modified slot dipole antenna fed by a coplanar waveguide for dual-frequency operation is presented. This antenna is formed by placing an additional slot dipole parallel to the coplanar waveguide-fed inductive slot dipole antenna, and inserting between them a pair of slot apertures shorter than the two slot dipoles. By varying the lengths of the protruded portions of these two slot dipoles, two operating frequency bands can be obtained. The tuning range of the frequency ratio of the two resonant frequencies is between 1.3 and 2.5. The proposed antenna possesses similar and well-behaved radiation performances in the two operating bands.

Introduction

Due to the advantages of the coplanar waveguide (CPW)-fed slot antennas, such as the uniplanar structure, wide bandwidth, bidirectional radiation, and easy integration with the RF front-end circuitry, many slot antenna elements using CPW as feedlines have been proposed [1]-[10]. Among them, however, only a few designs can provide dual- or multi-frequency characteristics [7]-[10]. Slot ring and slot loop antennas are commonly the fundamental structures used in [7]-[9], but they inherently possess higher cross-polarized radiation components. In this paper, a dual-band modified slot dipole antenna fed by a CPW is proposed to have satisfactorily low cross-polarization levels. The two resonant frequencies of this antenna can be separately located within a wide frequency range. Details of the antenna design and some simulated and measured results are presented and discussed.

Antenna Structure and Design

The configuration of the proposed modified slot dipole antenna fed by a CPW is shown in Fig. 1. This antenna is formed by placing an additional slot dipole (the upper slot pair with length L_1 and width S_1) parallel to the CPW-fed inductive slot dipole antenna (the lower slot pair with length L_3 and width S_3) and inserting a shorter slot pair in between. In order to produce dual-frequency characteristics, first of all, the length of the center slot pair L_2 must be chosen shorter than L_1 and L_3. Second, the length of the protruded portion of the lower slot pair (L_3–L_2) is set equal to a quarter guided-wavelength of the slotline at the lower resonant frequency. The total length of the protruded portion of the upper slot pair and the diagonal of the central aperture (L_1–L_2+D) will equal approximately a half guided-wavelength of the slotline at the upper resonant frequency. Moreover, by properly adjusting the width of the upper (lower) slot pair S_1 (S_3), the input matching condition at the corresponding resonant frequency can be improved. To facilitate the investigation in the next section, we vary only the length of the upper slot pair L_1, which is always kept shorter than L_3, and fix the other design parameters including L_2, L_3, and D. Thus, a fixed

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lower resonant frequency and a series of upper resonant frequencies corresponding to the constant $4(L_3–L_2)$ and various $2(L_1–L_2+D)$, respectively, can be observed.

Simulation and Measurement Results

Two prototype antennas are implemented and tested. Both are fabricated on the 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. In both cases, the lengths of the center and lower slot pairs L_2 and L_3 are fixed at 10 and 31 mm, respectively, leading to a lower resonant frequency of about 2.4 GHz. The other geometric parameters remaining unchanged in the two designs are listed as follows: $S_1 = 1.0$ mm, $S_2 = 4.0$ mm, and $S_3 = 0.3$ mm. The length of the upper slot pair L_1 is chosen to be 17 and 19 mm for the two prototype antennas. The simulated and measured input return losses of these two cases are depicted in Fig. 2, and they show excellent agreement. All simulations in this work are carried out by means of Ansoft Ensemble 8.0. The measured impedance bandwidths (return loss > 10 dB) of the lower frequency band for the two prototype antennas with $L_1 = 17$ and 19 mm are 6.1% (2.39-2.54 GHz) and 4.9% (2.38-2.50 GHz), respectively, while those of the upper band for the two cases are 9.9% (4.98-5.50 GHz) and 8.9% (4.30-4.70 GHz), respectively. Since the radiation performances of the two cases are similar, only those of the case with $L_1 = 19$ mm is demonstrated. The E- and H-plane patterns measured at the two resonant frequencies, 2.44 and 4.62 GHz, are shown in Figs. 3(a)-(d). The broadside and bidirectional radiation patterns are nearly the same at the two resonant frequencies, the cross-polarization levels remain satisfactory around the broadside directions in both principle planes, and the peak antenna gains measured at the lower and upper resonant frequencies are 6.2 and 6.9 dBi, respectively. To find the tuning range of the frequency ratio of the two resonant frequencies, a series of antennas with various L_1 (15, 21, and 23 mm) are designed and compared with the former two ($L_1 = 17$ and 19 mm). The simulated 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 lie in between 1.3 and 2.5.

Conclusion

A CPW-fed modified slot dipole antenna for dual frequency operation has been presented. By elongating or shortening the protruded portions of the upper and lower slot pairs, two operating frequency bands can be obtained. The tuning range of the frequency ratio of the two resonant frequencies is considerably wide and between 1.3 and 2.5. The broadside and bidirectional radiation patterns remain almost the same in both operating bands, and the cross-polarization levels are satisfactorily low around broadside directions. In addition to the dual-frequency characteristics, the uniplanar and simple structure make the proposed antenna ease of design and mass production.

Acknowledgements

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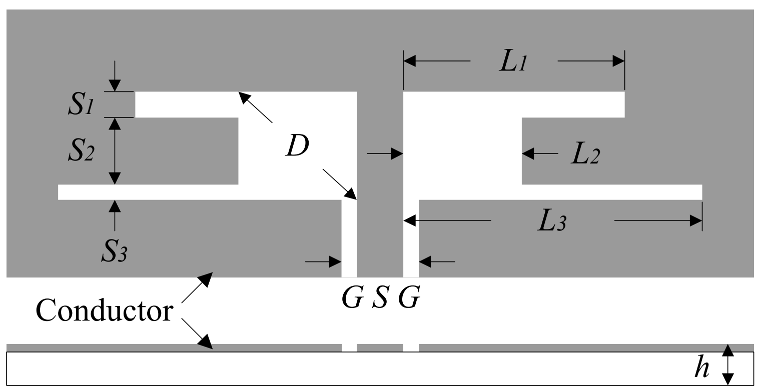


Fig. 1. Geometry of CPW-fed modified slot dipole antenna.

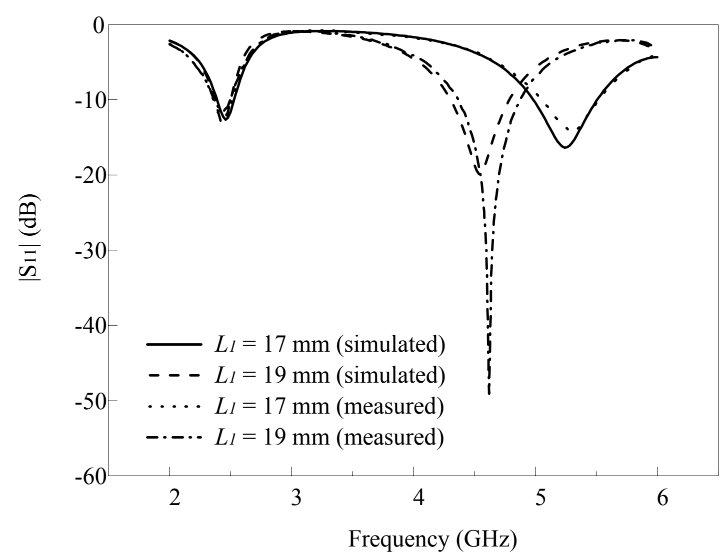
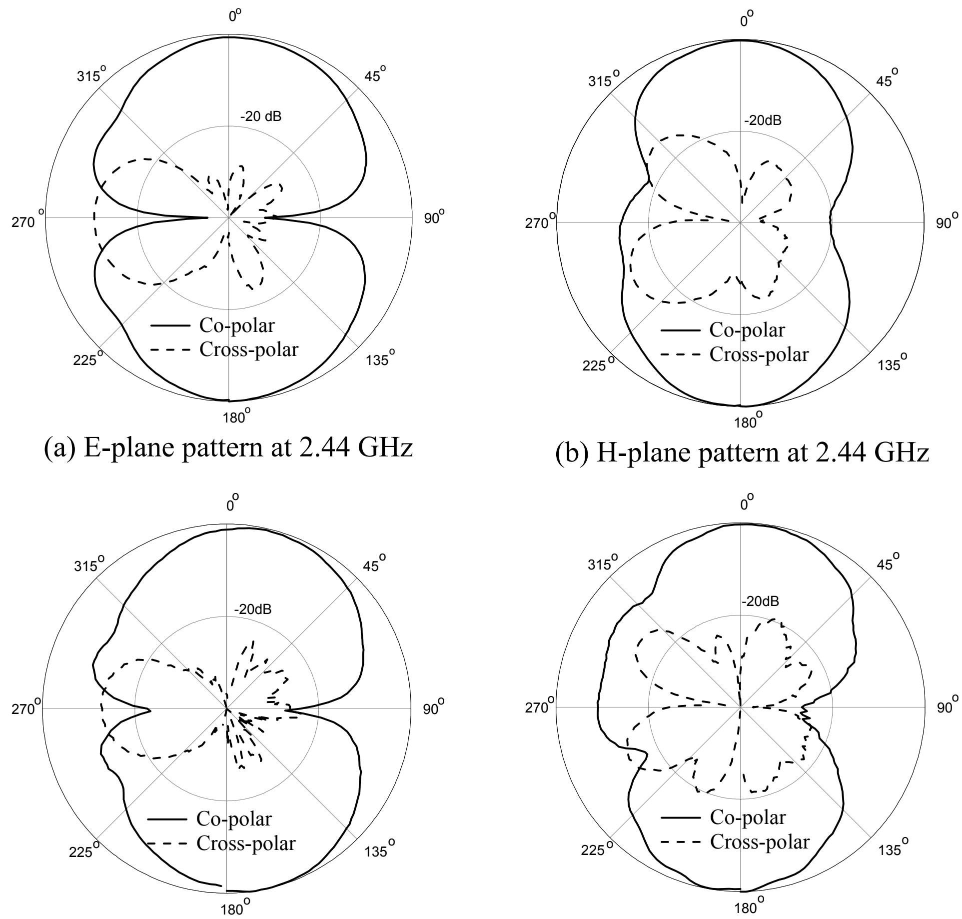


Fig. 2. Simulated and measured input return losses of the two prototype antennas.



(a) E-plane pattern at 2.44 GHz

(b) H-plane pattern at 2.44 GHz

(c) E-plane pattern at 4.62 GHz

(d) H-plane pattern at 4.62 GHz

Fig. 3. Measured radiation patterns of the prototype antenna with L_1 = 19 mm.

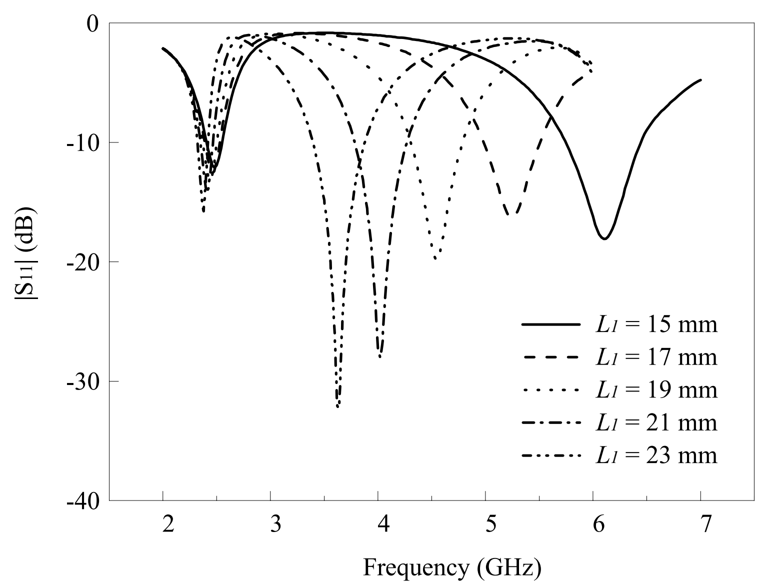


Fig. 4. Simulated input return losses of the proposed design for various L_1.