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BROADBAND CPW-FED ANTENNA WITH BAND-REJECTED CHARACTERISTIC FOR WLAN/WIMAX OPERATION

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Abstract—A novel single-layer broadband coplanar waveguide-fed antenna with band-rejected characteristic is proposed for WLAN/WiMAX operation. First, the broadband characteristic (2.43–5.97 GHz) is achieved by a CPW-fed patch antenna with a dual-Y slot. Then, a single slit is inserted on the radiating patch or ground plane to introduce a notched band. The proposed antenna has a compact size of $40 \times 25\,\mathrm{mm}^2$. The broadband characteristic and band-rejected functions of the proposed antennas are implemented and measured. Two types of antennas were studied. Measured notched-band impedance bandwidths (return loss < 10 dB) are 370 MHz and 1050 MHz, respectively, which satisfies the requirements for WLAN and WiMAX applications. Detailed design steps and experimental results for the designs are studied and investigated in this paper.

1. INTRODUCTION

Nowadays, with the rapid development of modern wireless communications, there has been increasing demand for broad dual- or multi-band operation for various portable wireless communication devices to provide more flexible applications. Antennas with broadband characteristic are often required in order to cover simultaneously several bands. Recently, several broadband antenna designs have been reported, such as wide-slot antennas, open-slot antennas and CPW-fed antennas. References [1–3] are wide-slot antennas, [4] is open-slot antenna, and [5]

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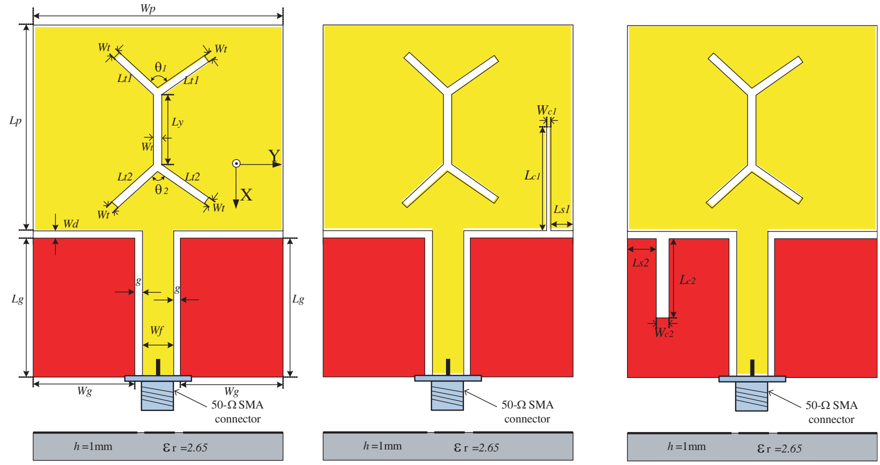
is CPW-fed antenna, but their bandwidths are not enough for WLAN and WiMAX applications. CPW-fed antennas in references [6–8] possess enough bandwidth for WLAN and WiMAX applications, but they have either large sizes or complicated structures. When these broadband antennas are applied to WLAN and WiMAX systems, it is better to introduce a notched-band to eliminate the unwanted bands. Several broadband antennas with band-rejected characteristics have been proposed lately [9–11]. The methods to achieve the rejected band include etching a slit on the ground plane [9] or on the radiating patch [10] and combining a strip on the ground plane [11], among which references [9, 11] are implemented with microstrip-fed and the center frequency of notched-band in reference [10] is allocated below the 3 GHz.

In this paper, a novel broadband CPW-fed antenna is proposed with a dual-Y slot etched on the radiating patch. Then, a design of the band-rejected function has been proposed by inserting a single slit on the radiating patch or on the ground plane to achieve a notched-band between 3.7 GHz and 5 GHz. By adjusting the dimensions of the slit on the radiating patch or on the ground plane, two planar antennas with different band-rejected characteristics have been obtained. After a comparison, a wider notched-band bandwidth can be obtained when etching the slit on the ground plane. The proposed antennas have been simulated, fabricated and measured. The radiation patterns and antenna gains are presented. Details of the design process and parametric studies are also discussed below.

2. ANTENNA ANALYSIS AND DESIGN

The schematic diagram of the proposed initial broadband antenna (antenna 1) is illustrated in Figure 1(a). The antenna is designed and fabricated on a substrate with relative permittivity of 2.65, thickness of 1 mm and total area of $40 \times 25\,\text{mm}^2$. A coplanar waveguide structure, which has a signal strip of width W_f and a gap distance of g between the signal strip and the coplanar ground plane, is used to feed the antenna. Two equal sized coplanar grounds with dimension of $L_g \times W_g$ are symmetrically situated on each side of the central feed strip. The radiating patch has a size of $L_p \times W_p$. In order to achieve a broadband enhancement, a dual-Y slot is etched on the radiating patch. After that, the current distributions on the upper of the dual-Y slot become strong. It increases the resistance and decreases the reactance of the original antenna at upper frequencies, which can enhance the bandwidth. The dual-Y slot consists of two asymmetrical V-shaped slots connected by a vertical slot with the length of L_y. The width of the dual-Y shaped slot is W_t. The length and included angle of



(a) antenna 1 (b) antenna 2 (c) antenna 3

Figure 1. Geometries of the proposed antennas.

the upper one are Lt_1 and θ_1, and the lower are Lt_2 and θ_2. The distance between the ground plane and radiating patch is W_d. By inserting the dual-Y slot, a bandwidth enhancement characteristic can be achieved in this design. The optimized parameters obtained with the aid of Ansoft HFSS 12 are as follows: $L_p = 24\,\text{mm}$, $W_p = 25\,\text{mm}$, $L_g = 14\,\text{mm}$, $W_g = 10.45\,\text{mm}$, $W_f = 3.5\,\text{mm}$, $W_d = 2\,\text{mm}$, $g = 0.3\,\text{mm}$, $W_t = 1\,\text{mm}$, $Lt_1 = 7.7\,\text{mm}$, $Lt_2 = 8.8\,\text{mm}$, $L_y = 9.2\,\text{mm}$, $\theta_1 = 60°$ and $\theta_2 = 60°$. To demonstrate the effect of the dual-Y slot on the bandwidth of the antenna, the simulated return loss curves with and without the dual-Y slot and the measured return loss curve with the dual-Y slot are shown in Figure 2. With the help of the dual-Y slot, the upper frequency can be extended from 4.62 GHz to 5.97 GHz.

To achieve band-rejected characteristic, a slit needs to be etched on the radiating patch or on the ground plane. In this letter, both methods are taken respectively. So, two broadband antennas with notched-band are designed in this article. The geometries of the two antennas (antennas 2 and 3) with band-rejected characteristic are shown in Figures 1(b) and (c), respectively. The slit acts as a resonator, and the resonant frequency mainly depends on the length of the slit. The lengths Lc_1 and Lc_2 are about a half or a quarter of the wavelength corresponding to the resonant frequency [12, 13]. At the notch frequency, the current around the slit becomes strong, which causes impedance variations to form the desired notched band. The widths Wc_1 and Wc_2 as well as locations Ls_1 and Ls_2 are chosen to be 0.5 mm, 1 mm, 1.5 mm and 4.5 mm, respectively.

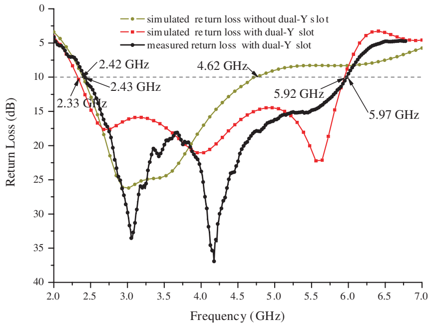


Figure 2. Return loss curves of the antennas with/without the dual-Y slot.

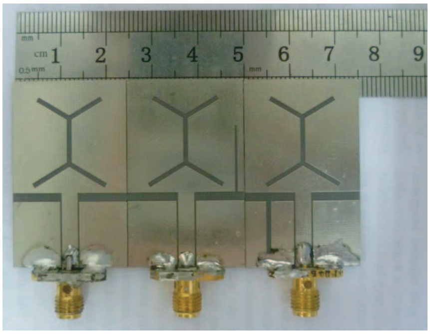


Figure 3. Photograph of the proposed antennas.

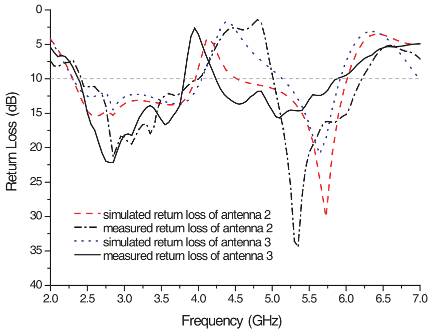


Figure 4. Simulated and measured return loss curves of the proposed antennas.

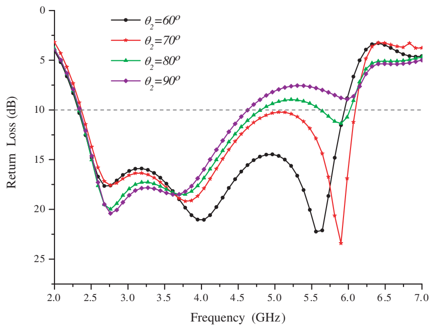


Figure 5. Simulated return loss curves for varying values of θ_2.

3. RESULTS AND DISCUSSION

The proposed antennas have been fabricated and their photographs are shown in Figure 3. The measurements are made with a WILTRON 37269A vector network analyzer. Measured impedance bandwidth (return loss $>$ 10 dB) is 3540 MHz (2.43–5.97 GHz) for antenna 1 shown in Figure 2. In Figure 4, measured impedance bandwidths of notched-bands are 370 MHz (3.74–4.11 GHz) for antenna 2 and 1050 MHz (3.73–4.75 GHz) for antenna 3. It validates that the bandwidth of the notched-band of antenna 3 is wider than that of the antenna 2.

The broadband characteristic of antenna 1 and the band-rejected

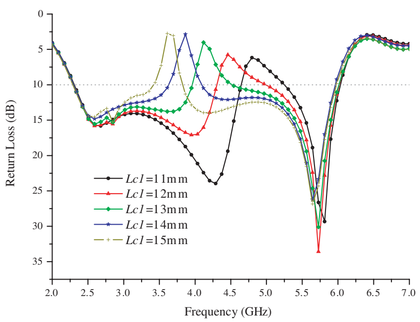


Figure 6. Simulated return loss curves for varying values of Lc_1.

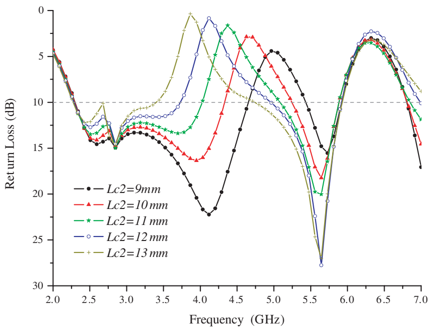


Figure 7. Simulated return loss curves for varying values of Lc_2.

Table 1. The effects of Lc_1 and Lc_2 on notched characteristics.

Parameter	Rejected Center Frequency (GHz)	Rejected Bandwidth (MHz)
$Lc_1 = 11\,\mathrm{mm}$	4.92	630
$Lc_1 = 15\,\mathrm{mm}$	3.61	350
$Lc_2 = 9\,\mathrm{mm}$	5.96	740
$Lc_2 = 13\,\mathrm{mm}$	3.86	1420

functions of antennas 2 and 3 are discussed. Of all parameters of the dual-Y slot, the included angle θ_2 has the strongest effect on the broadband characteristic. From Figure 5, it can be seen that θ_2 affects the upper band significantly. For antenna 2 and 3, the lengths of the slits (Lc_1 and Lc_2) are the vital parameters for the notched bands. Figures 6 and 7 depict the two circumstances. Figure 6 shows that with the increasing of Lc_1, the notch frequency shifts down obviously, and Lc_2 acts like Lc_1 in Figure 7. Also from Figures 6 and 7, we can see that the notched-band bandwidth of antenna 2 becomes narrower as Lc_1 decreases, while the bandwidth of antenna 3 becomes wider as Lc_2 decreases. Typical dimensions of Lc_1 and Lc_2, center frequencies of the notched bands and notched-band bandwidths for antennas 2 and 3 are listed in Table 1. By choosing proper values of $Lc_1 = 13\,\mathrm{mm}$ and $Lc_2 = 11\,\mathrm{mm}$, the proper band-rejected characteristics can be obtained.

The simulated far-field radiation patterns of the proposed antenna 2 at the several typical operation frequencies are also investigated. Figure 8 plots H plane and E plane radiation patterns

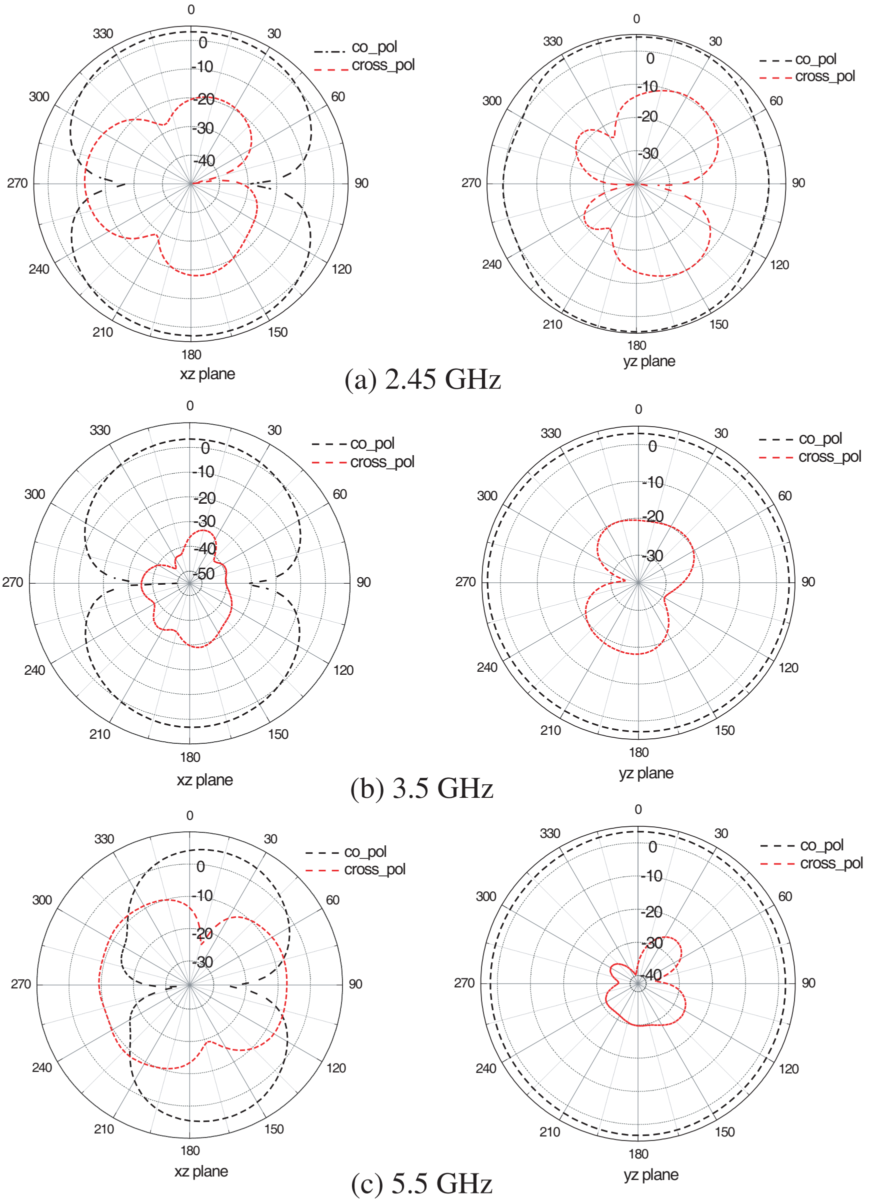


Figure 8. Radiation patterns for the proposed antenna 2 at (a) 2.45 GHz, (b) 3.5 GHz, and (c) 5.5 GHz.

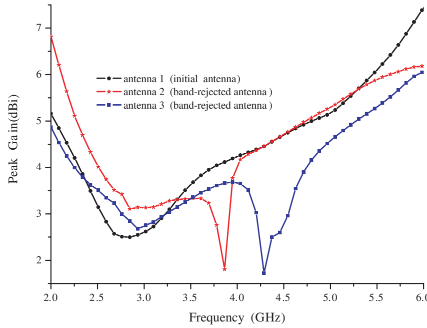


Figure 9. Peak gains of the proposed antennas across frequency.

at 2.45/3.5/5.5 GHz. It can be seen that the presented antenna, in general, shows a monopole-like radiation patterns. In addition, the simulated peak gains are also depicted in Figure 9. It can be observed that the significantly gain reductions over the rejected band are clearly shown in the figure.

4. CONCLUSION

Two novel broadband CPW-fed antennas with different band-rejected characteristics are designed, fabricated and measured in this paper. The measured results show a good agreement with the simulated ones. By inserting a slit on the radiating plane or ground plane, the band-rejected characteristic can be achieved. From the measured results, the band-rejected characteristic introduced by the slit etching on the ground plane is better than that on the radiating plane. Both the two types of antennas with notched-band are suitable for WLAN and WiMAX operation.

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