Design of Compact CPW-Fed Planar Antenna with Dual Notched Bands Using Slotted Conductor-Backed Plane for UWB Application

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Abstract **─** A compact design of a Coplanar Waveguide Fed (CPW-Fed) monopole antenna with Ultra Wideband (UWB) performance and dual band-notched characteristics is proposed. Dual band-notched characteristics are achieved by U-shaped slot inside the slotted conductor-backed plane and a pair of mirror rectangular-shaped slots at the two sides of the truncated conductor-backed plane. Also, wider impedance bandwidth can be achieved with this structure. The proposed antenna has a small size of 18×18 mm^2 and measured to cover the bandwidth for UWB (2.7-14.5 GHz) for VSWR < 2, except the bandwidths of 3.1-3.6 for WiMAX and 5-6 GHz for WLAN. The antenna has an omnidirectional radiation across the whole ultra wideband as validated by the measured radiation pattern and gain.

Index Terms – Coplanar Waveguide (CPW) antennas, frequency band-notched function, Ultra Wideband (UWB) antenna.

I. INTRODUCTION

Quick development of wireless communication in the field of UWB technology and its applications has increased demand in commerce and industry. There has been great progress in the design of ultra wideband antennas and devices in recent years [1]. On the other hand, the printed monopole antenna exhibits very main parameters in designing UWB antennas, such as easy to manufacture structure, compact size, low cost and omnidirectional radiation pattern across the band from 3.1 GHz to 10.6 GHz [2]. However, there are several narrow bands that might become potential interferences within the UWB frequency spectrum, such as IEEE802.16.

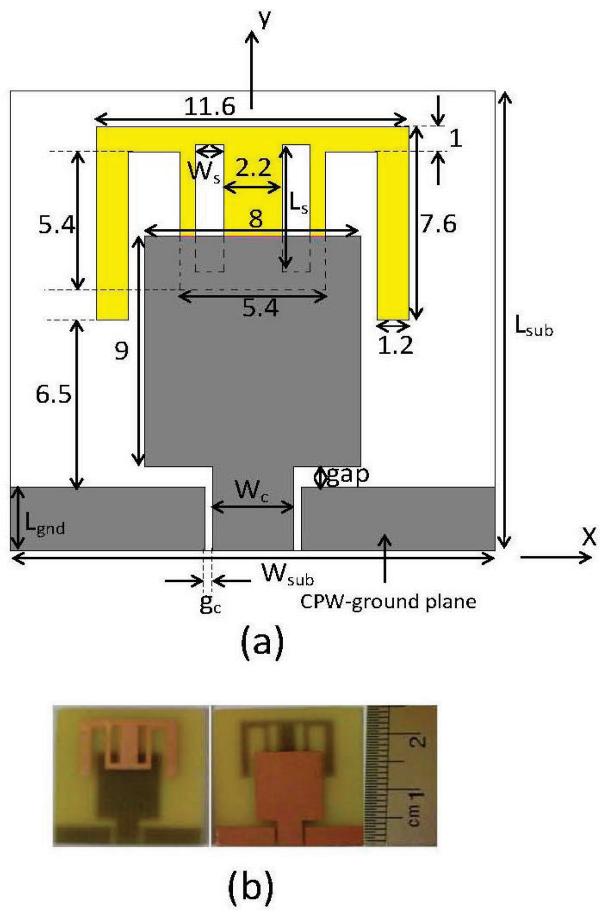

Fig. 1. Geometry of the propose antenna: (a) dimensions (units: mm) and (b) photograph of fabricated antenna.

The UWB antenna with band stop performance is

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concerning the UWB antenna where band-notched characteristics have been reported; WiMAX (3.3-3.6 GHz) and the Wireless Local Area Network (WLAN) for IEEE802.11a (5.15-5.825 GHz).

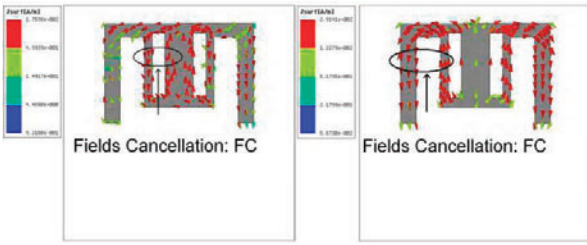

Fig. 2. Simulated current distribution of the dual band-notched monopole antenna at: (a) 3.3 GHz and (b) 5.5 GHz.

These designs use different types of slots, slits and parasitic elements in the radiator, the ground plane or even in the feeder to achieve the required band-notching characteristics with limited impact on the required pass band [3-12].

In this paper, a novel compact CPW-Fed UWB antenna with dual band-notch characteristics and increased bandwidth is presented. In this designed antenna, the target is to present a compact structure with a step-by-step design procedure. By having a pair of mirror rectangular-shaped slots etched and a U-shaped slot embedded on the conductor-backed plane, a dual band-notched characteristic is created. Wider impedance bandwidth is achieved by use of the final structure of conductor-backed plane, which provides a wide usable fractional bandwidth of more than 137% (2.7-14.5 GHz). Measured results of the realized antenna with the different structures of conductor-backed plane are presented.

II. ANTENNA DESIGN

Figure 1 shows the geometry and configuration of the proposed antenna with $W_{sub} \times L_{sub}$ dimensions. The proposed antenna with compact dimensions of 18×18 mm^2, is constructed on a 0.8 mm thickness FR4 substrate with relative dielectric constant ε_r = 4.4 and loss tangent of 0.02. The antenna is fed by a 50Ω Coplanar Waveguide (CPW). A rectangular patch with the dimensions of 8×9 mm^2 is connected to the CPW ground plane. In the first step of the design, the dimensions of the substrate, radiator and CPW ground plane are optimized using the software HFSS for an UWB frequency coverage.

For the impedance matching, the distance between the patch and the ground plane is indicated with a gap, which provides suitable control between the lower edge patch and the ground plane. The optimum gap between the radiator and the ground plane is 0.3 mm. To modify the performance of the antenna by creating two sub-bands at the WiMAX (3.3-3.6 GHz) and WLAN (5.15-5.825 GHz), the conductor-backed is slotted in the manner shown in Fig. 1. A pair of mirror rectangular-shaped slots has created the first notched band centered at 3.3 GHz, whereas the U-shaped slot inside the conductor-backed is responsible for making the second notched band centered at 5.5 GHz. The photograph of the fabricated band-notched UWB antenna with the final optimal design is shown in Fig. 1 (b).

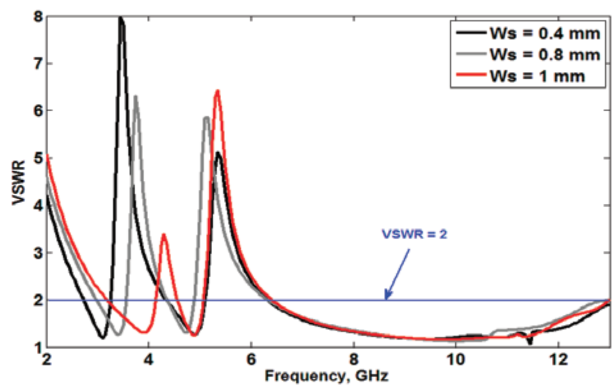

Fig. 3. Simulated band-rejection of the proposed antenna for various values W_s.

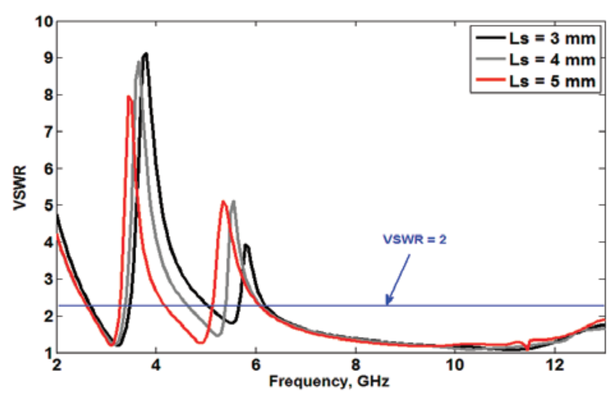

Fig. 4. Simulated band-rejection of the proposed antenna for various values L_s.

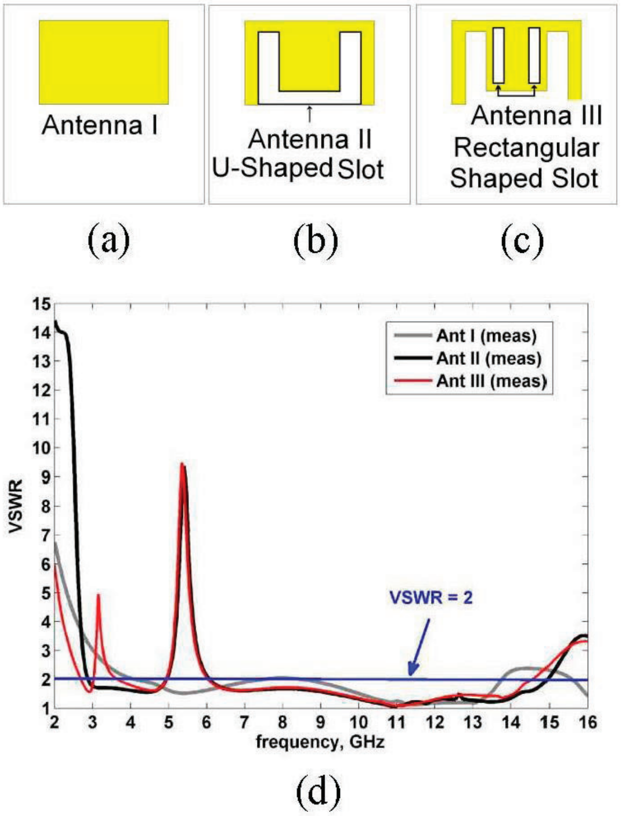

Fig. 5. Geometry of conductor-backed plane: (a) ordinary conductor-backed plane, (b) with U-shaped slot, (c) with a pair of mirror rectangular-shaped slots and (d) measured VSWR characteristics for a, b and c.

The modified conductor-backed is designed to achieve better impedance matching over the entire UWB frequency band.

III. RESULT AND DISCUSSIONS

The simulated results are obtained using the electromagnetic software Ansoft HFSS. Figure 2 shows the current distribution at the first and second notch frequency. It is clear from Fig. 2 (a) that the current flows inside conductor-backed in opposite directions at the two edges of the rectangular slots at 3.3 GHz. Thus, the total effective radiation is very low and a notched band is achieved. In Fig. 2 (b), the surface current at 5.5 GHz at the indoor U-shaped slot is in reverse direction to the current in the outer edges of the slot. Thus, the overall radiation at this band is very limited and a second notched band is achieved.

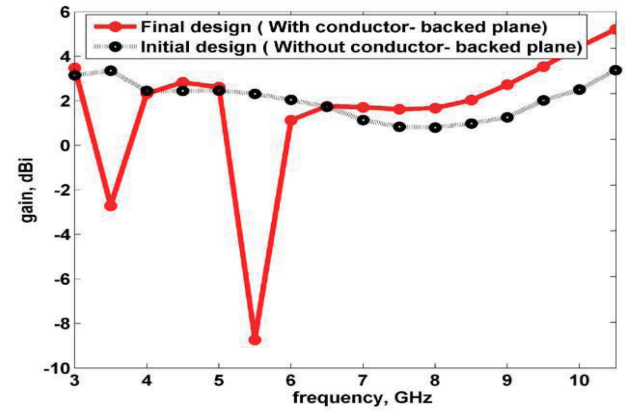

Fig. 6. The measured gain of the proposed antenna, with and without conductor-backed plane.

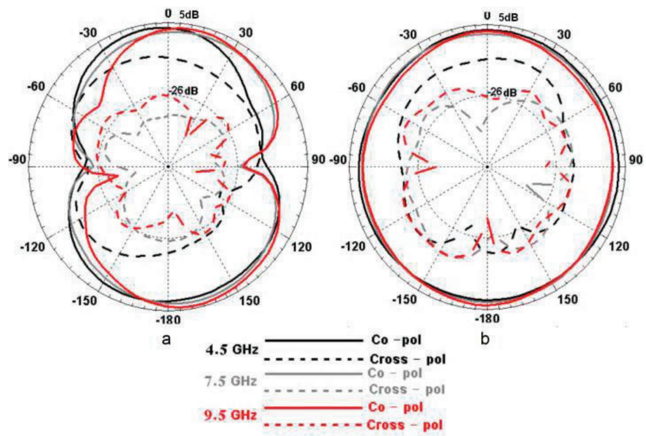

Fig. 7. Measured radiation pattern of the proposed antenna: (a) on E-plane and (b) on H-plane.

Through parametric study, the optimum value for each parameter is investigated. The width of the rectangular-shaped slots inside the conductor-backed plane is the main parameter in determining the first band-notched function. The effect of varying the size of the W_s is indicated in Fig. 3. As shown, it is clear that when W_s increases from 0.4 to 1mm, the first band-notched frequency shifts down from around 4.1 to 3.28 GHz. To generate the second band-notched characteristic for WLAN, the length of rectangular slot is investigated. The simulated VSWR curve with various values of the L_s is plotted in Fig. 4. The results indicate that the second band-notched of the proposed antenna can be effectively controlled by adjusting L_s.

The developed antenna that has the dimensions W_{sub} = 18 mm and L_{sub} = 18 mm was tested using an Agilent 8722ES Vector Analyzer (VNA). The two bands centered at 3.3 GHz and 5.5 GHz are notched with VSWR that is larger than 5 for the first band and 10 for the second band. However, it is clear from Fig. 5 (a) that the antenna has a poor performance by use of the rectangular-shaped structure, which should be part of the UWB spectrum. To improve the performance at that band and to obtain dual band-notched, a slotted conductor-backed structure is indicated at the bottom layer in Fig. 5 (c). By use of the design, it is worth mentioning that using the slotted conductor-backed plane in the manner shows in Fig. 5 (c); it not only enables the rejection of the undesired sub-bands, but it also improves the performance at the upper frequency band. Figure 5 (d) clearly shows that the impedance bandwidth of proposed antenna very well covers the intended VSWR < 2 from 2.7 GHz to 14.5 (137%) GHz and has dual band-notched characteristics (VSWR > 2) in 3.1-3.6 GHz and 5-6 GHz. Also, it can be observed that by using the filter structures inside conductor-backed, the lowest frequency is significantly decreased from 4 GHz to 2.7 GHz. Figure 6 shows the measured maximum antenna gain from 3 GHz to 11 GHz for the developed antenna. The simulated gain of a rectangular patch structure also confirms the effect of the utilized approach in the rejection of two sub-bands. Figure 6 indicates that the realized dual band-notched antenna has good gain flatness, except at the two notched bands. As shown in Fig. 6, gain decreases the measure drastically at the frequency bands. Figure 7 shows radiation patterns for three different frequencies, 4.5, 7.5 and 9.5 GHz of the UWB band in H-plane (xoz-plane) and E-plane (yoz-plane); for the antenna with double band notches. Figure 7 approximately exhibits an omnidirectional radiation pattern in H-plane and a dipole-like radiation pattern in the E-plane.

IV. CONCLUSION

A compact CPW-Fed printed monopole antenna with ultra wideband performance and dual band-notched characteristics has been presented. The first notched band aimed at preventing any interference with existing WiMAX systems and is achieved by using a pair of mirror rectangular-shaped slots in the conductor-backed plane. The second notched band aimed at preventing the interference with the 5 GHz WLAN systems and is achieved by use of the U-shaped slot embedded inside the slotted conductor-backed plane. Experimental results show that the fabricated antenna with proper dimensions and aforementioned characteristics such as small size, light weight and good omnidirectional radiation patterns, is a very good candidate for UWB applications.

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