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Compact Planar UWB Antenna with Dual Notched Bands Using Slotted Conductor-backed Plane

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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. 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 ultrawideband as validated by the measured radiation pattern and gain.

Keywords: Ultra wideband (UWB) antenna, coplanar waveguide (CPW) antennas, frequency band notched function

INTRODUCTION

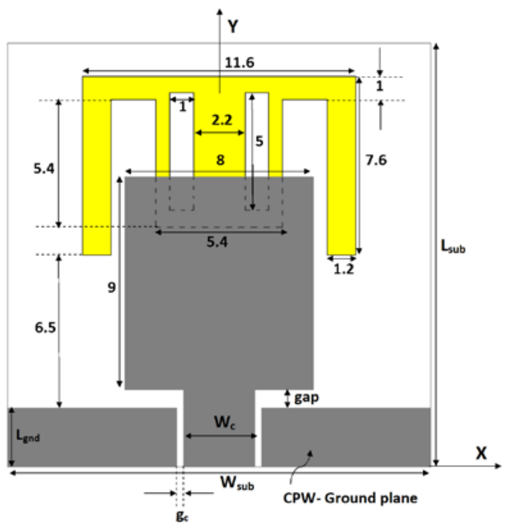
Quick development of wireless communication in the field of UWB technology and its applications has increased demand in commerce and industry. There has been great progress in the design of ultra wideband antennas and devices in recent years [1]. On the other hand, the printed monopole antenna exhibits 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 band that might become potential interferences within the UWB frequency spectrum, such as IEEE802.16 WiMAX (3.3-3.6 GHz) and the wireless local area network (WLAN) for IEEE802.11a (5.15-5.825 GHz), so the UWB antenna with band stop performance is required. Several designs in the literature concerning the UWB antenna with band-notched characteristics have been reported. Those 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 [3-10].

In this letter, 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 using of 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 difference structures of conductor-backed plane are presented.

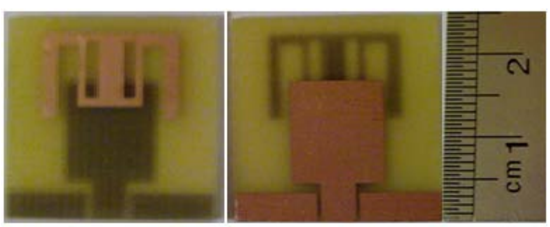
MATERIALS AND METHODS

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 $\varepsilon_r = 4.4$ and loss tangent 0.02. The antenna is fed by a 50 Ω coplanar waveguide (CPW). A rectangular patch with the dimensions of 8 × 9 mm^2 is connected to the CPW ground plane. 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 0.3mm. 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 Figure 1. A pair of mirror rectangular-shaped slots is 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 Figure 1b. The modified conductor-backed is designed to achieve better impedance matching over the entire UWB frequency band.



(a)



(b)

Figure 1. Geometry of the propose antenna. (a) Dimensions(units: mm), (b) Photograph of fabricated antenna

RESULTS AND DISCUSSION

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 Figure 2a 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 thus a notched band is achieved. In Figure 2b, 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.

The developed antenna that has the dimensions W_{sub} =18mm and L_{sub} = 18mm 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 Figure 3a that the antenna has a poor performance by using of 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 bottom layer in Figure 3c. Figure 3d clearly shows that the impedance bandwidth of proposed antenna very well covers the intended VSWR < 2 from 2.7 GHz to 14.5 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 this filter structures inside conductor-backed, the lowest frequency is significantly decreased from 4 to 2.7 GHz. Figure 4 shows the measured maximum antenna gain from 3 to 11 GHz for the developed antenna. The simulated gain of a rectangular patch structure is also shown to confirm the effect of the utilized approach in the rejection of two sub-bands. The figure indicates that the realized dual band-notched antenna has good gain flatness except at the two notched bands. As shown in Figure 4, gain decreases drastically at the frequency bands. Figure 5 shows the measured radiation pattern 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. The figure is approximately exhibits an omnidirectional radiation pattern in H-plane and a dipole-like radiation pattern in the E-plane.

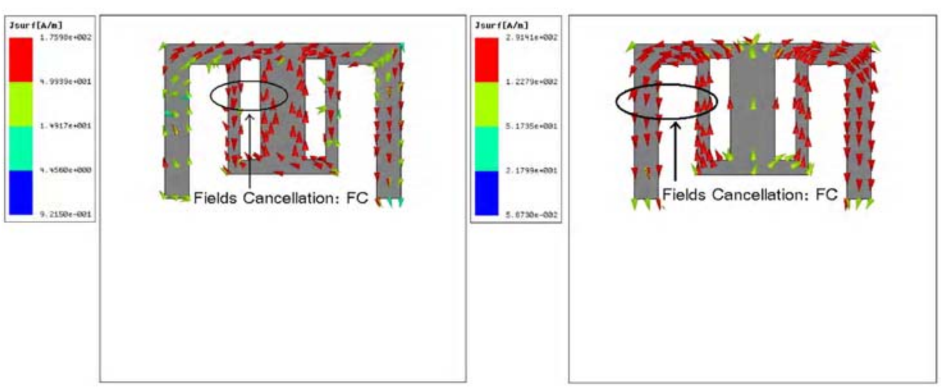
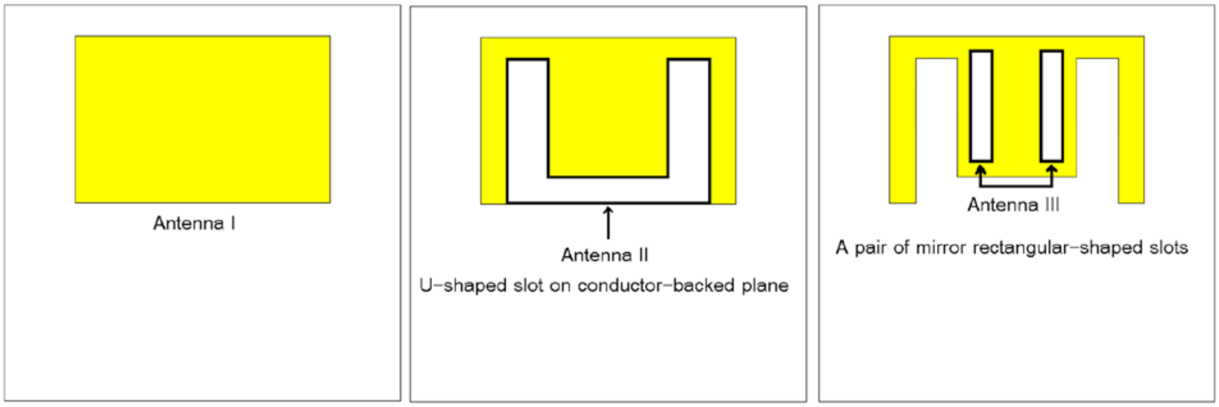


Figure 2. Simulated current distribution of the dual band-notched monopole antenna at (a) 3.3 GHz, (b) 5.5 GHz



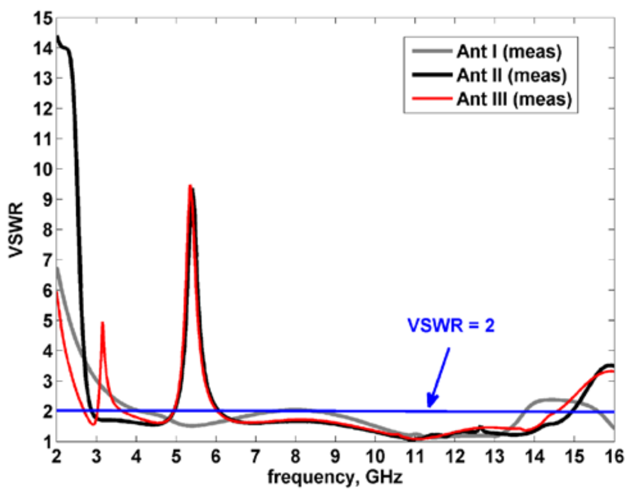


Figure 3. Geometry of Conductor-backed planes. (a) Ordinary conductor-backed plane, (b) With U-shaped slot, (c) With a pair of mirror rectangular-shaped slots, and (d) Measured VSWR characteristics for a, b, c

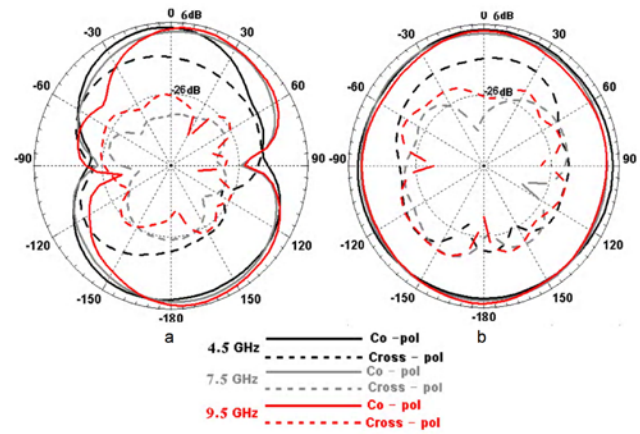


Figure 5. Measured radiation pattern of the proposed antenna. (a) On E-plane and (b) On H-plane

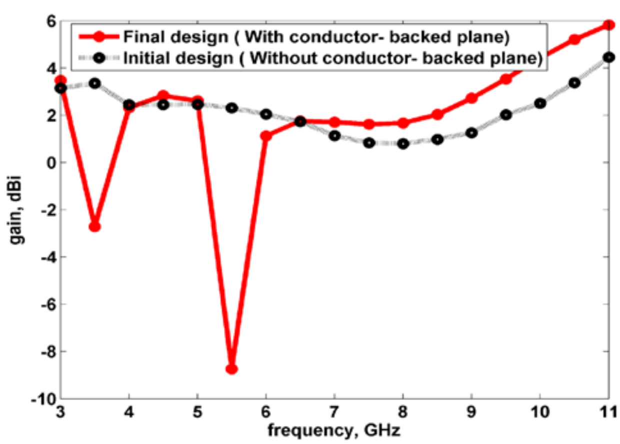


Figure 4. The measured gain of the proposed antenna with and without conductor-backed plane

CONCLUSION

A compact CPW-fed printed monopole antenna with ultrawideband performance and dual band-notched characteristics has been presented. The first notched band aimed at preventing any interference with existing WiMAX systems is achieved by using a pair of mirror rectangular-shaped slots in the conductor-backed plane, which exempt from interfaces. The second notched band aimed at preventing the interference with the 5 GHz WLAN systems is achieved by using of 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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