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COMPACT MONOPOLE ANTENNA WITH TWO BANDS—NOTCHED CHARACTERISTIC FOR ULTRA-WIDEBAND APPLICATIONS

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Received 6 March 2011

ABSTRACT: *In this article, we present a novel small ultra-wideband microstrip-fed planar monopole antenna composed of a hexagonal patch, a truncated stub, a step ground structure, and a conductor back plane in the shape of a window. Impedance bandwidth of the proposed antenna is ∼136% with voltage-standing wave ratio <2 in the frequency range of 2.7–14.3 GHz over an UWB frequency range that satisfies FCC's requirements for an antenna.* © 2011 Wiley Periodicals, Inc. Microwave Opt Technol Lett 53:2817–2821, 2011; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.26409

Key words: *planar monopole antenna; microstrip-fed; two band notch antennas; ultra wide band antenna*

1. INTRODUCTION

Ultra-wideband (UWB) transmission is a widely used technology in radar and remote sensing applications and has become the focus of wireless communication [1–3]. After the approval of FCC for the commercial use of 3.1–10.6 GHz for UWB systems in 2002, the design of these antennas for wireless communication applications has gained a great attention and impetuses and the most exciting tasks in these systems. Direct transmission and receiving very short pulses with several gigahertz bandwidths are the main ideas [4, 5].

The UWB technology is attracting considerable interests and research activities in recent years because of the following characteristics: UWB operation bandwidth, high data transmission rate of 100 M/bps to 1 G/bps over short distances, small size, low power consumption (∼200 μW) [6], omnidirectional pattern, low group delay, constant gain, and linear phase response [7, 5, 8, 9]. It is a means of expanding capacity from the already heavily used wireless bandwidth and that the proposed antenna has mentioned specification. However, the existing of some narrow band wireless systems such as: WLAN and hyperlink using IEEE 802/11a protocol, operating at (5.15–5.825 GHz) bands [7] and worldwide interoperability for microwave access WiMAX (3.15–3.8 GHz) can cause the performance degration of UWB systems due to the absence of a band pass filters.

In most of the communication systems, an antenna is followed by a filter or vice versa. However, using a filter is probably not the best choice when the size matters; it is extremely desirable to integrate an antenna and microstrip filter into a single module. Anyway, the use of a filter will increase the complexity of the UWB system, so different antenna design methods have been proposed to produce the band notch characteristic in the UWB bands. To overcome electromagnetic interference between the UWB and the WLAN systems, various UWB antennas with the desired features designed by different researchers who design compact antennas have been reported [7].

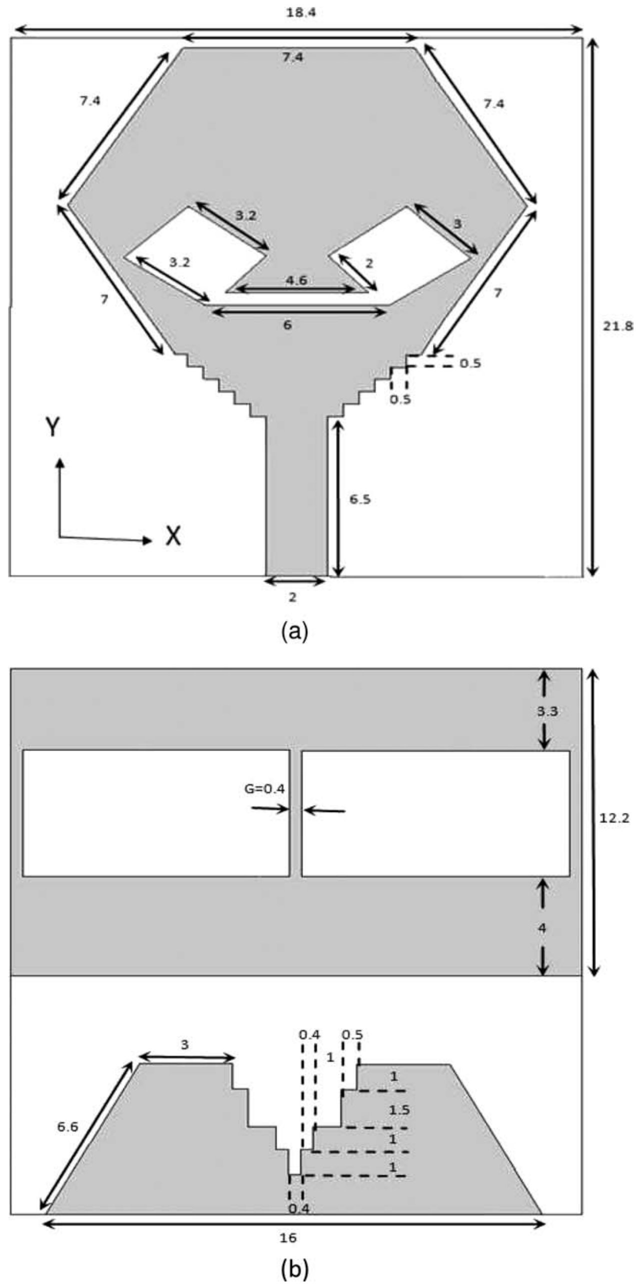

Figure 1 Geometry of the proposed antenna. (a) Top view (mm) and (b) bottom view (mm)

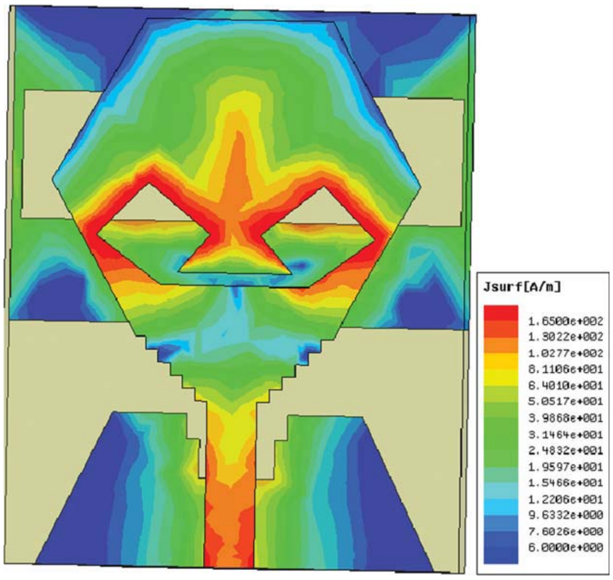

Figure 2 The photograph of the simulation by HFSS software. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

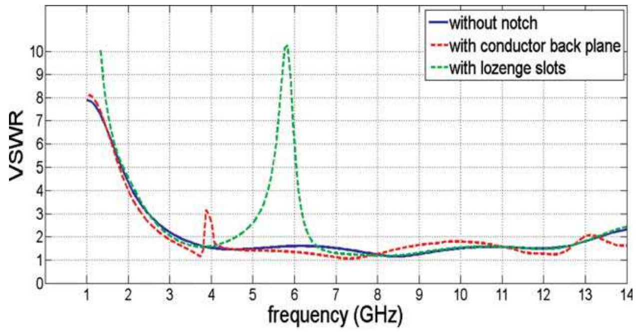

Figure 4 Simulation of the antenna's VSWR in different ways. (Without notch, with conductor back plane, with lozenge slots). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

Among these designs, etching of different kinds of slots on the patch or ground of antenna, such as U shape [10] and V shape [11, 12], is most often used. Other methods include adding a parasitic element, using folded strips to the antenna and etching split ring resonator [13]. Embedding a resonator cell in the microstrip line or coplanar wave guide also can effectively filter the undesired band.

In this article, a hexagonal microstrip monopole antenna is proposed. Results show that the dual-band notched antenna can operate in a band from 2.7 to 14.3 GHz with the first band notched at a center frequency of 3.54 GHz for WiMAX and the second band notched at a center frequency of 5.43 GHz for WLAN systems with voltage-standing wave ratio (VSWR) <2, and the radiation pattern is almost omnidirectional over the entire UWB bands.

2. ANTENNA DESIGN

Figure 1 shows the physical geometry of the suggested UWB antenna defining its salient parameters and dimensions. The proposed antenna consist of hexagonal radiating patch connected to a microstrip stepped feed line on one side of the dielectric substrate, and two lozenge slots that are connected to each other to achieve a dual-band notched characteristic for an UWB antenna.

If we do not connect slots to each other, we could not cover the band notches correctly because of the current perturbation, so we consider these lozenge slots with the mentioned size in Figure 1(a) to reject the WLAN band. Figure 2 shows the simulated photograph and current radiation at 6 GHz, and Figure 3 shows the top and bottom views of the fabricated antenna that constructed on FR4 substrate with thickness of 1 mm, relative dielectric constant of $\varepsilon_r = 4.4$, and loss tangent of around 0.02. The antenna has a small size, that is, 18.4×21.8 mm^2. The width of the microstrip feed line is fixed at 2 mm to achieve 50-Ω characteristic impedance.

The use of low-cost FR4 as substrate introduces some additional complexity on the antenna design [13]. This additional complexity is due to the inaccuracy of the FR4 relative constant and its high loss tangent. Variation of the FR4 electrical permittivity can shift the operating frequency in WiMAX or WLAN bands.

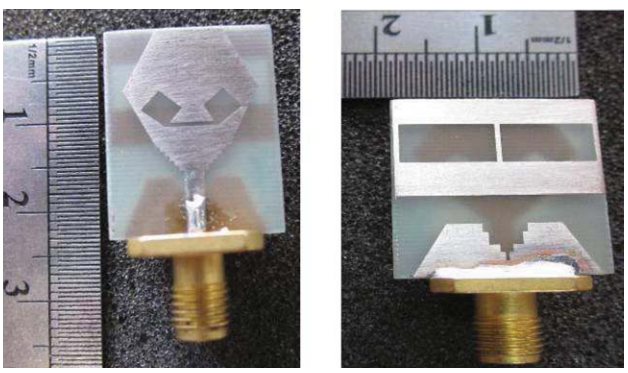

Figure 3 Photograph of the fabricated antenna. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

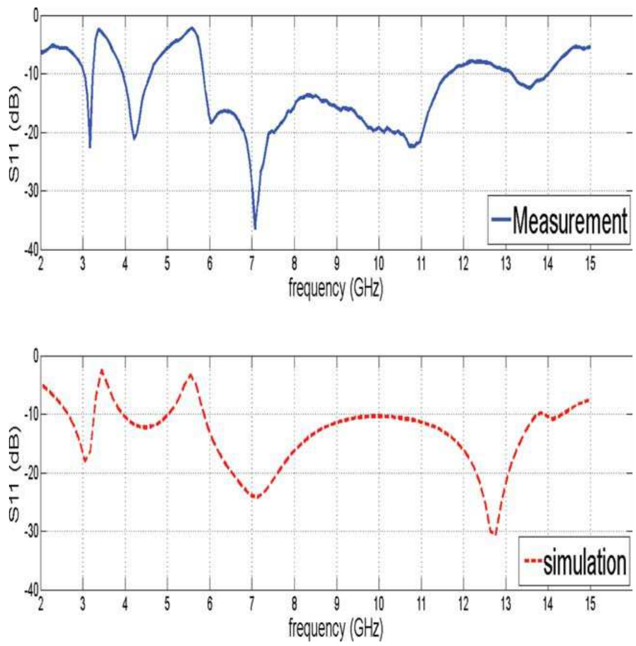

Figure 5 Simulation and measurement results of the antenna's reflection coefficient. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

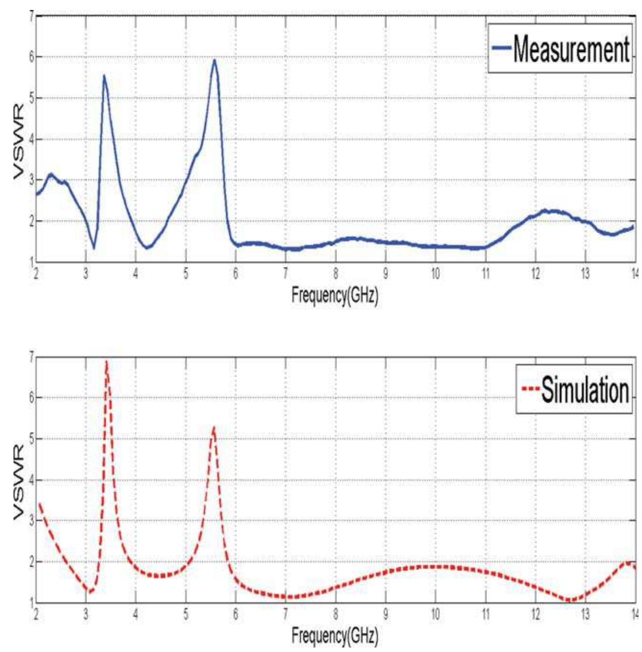

Figure 6 Simulation and measurement results of the antenna's VSWR. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

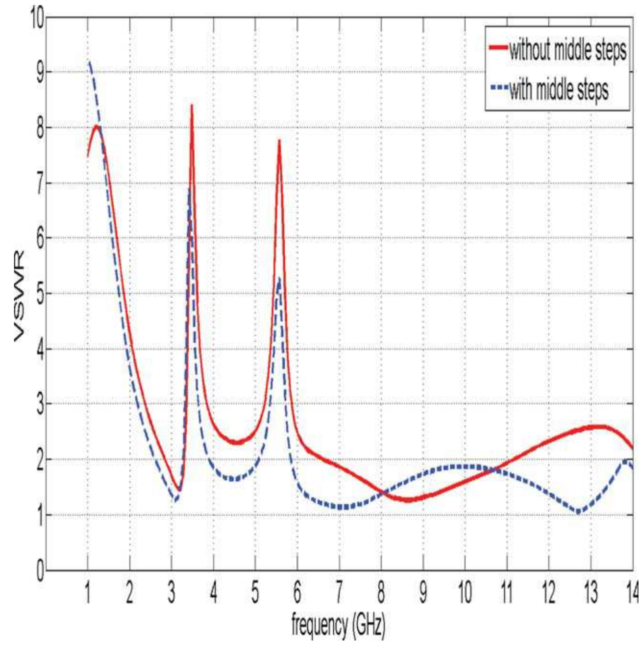

Figure 8 The effects of stepped in the ground plane. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

On the front surface of the substrate, a hexagonal patch with step parts with size 14.7×14.9 mm^2 is printed. The hexagonal patch has a distance of 0.5 m to the ground plane with length of 6 m printed on the back surface of the substrate.

With regard to the defected ground structures, the creating steps in the ground plane provide an additional current path. Moreover, this structure changes the inductance and the capacitance, which in turn lead to the change in band width [13]. We removed the corner of the ground plane to match the impedance band width in higher frequencies. Therefore, by truncating the ground plane and carefully adjusting its parameter, a much enhanced impedance bandwidth may be achieved.

As illustrated in Figure 1(b), conductor back plane is printed with a parasitic rectangular structure in the shape of a window in the size of 12.2×18.4 mm^2.

It is placed under the radiating patch which is also symmetrical with respect to the width direction. The conductor back plane perturbs the resonator response [14] and also acts as a parasitic resonant structure electrically coupled with the hexagonal monopole. At the notch frequency, the current flows more dominantly around the parasitic element, and is oppositely directed between the parasitic element and the radiation patch [15]. As a result, it behaves like a band rejection network.

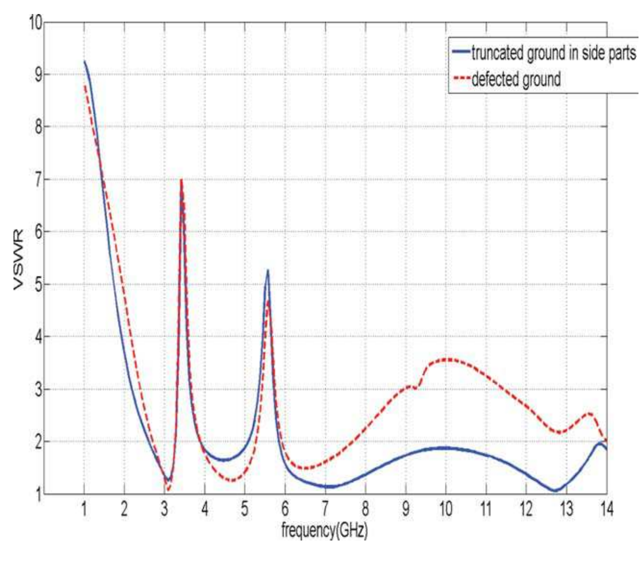

Figure 7 The truncated ground in side parts and defected ground. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

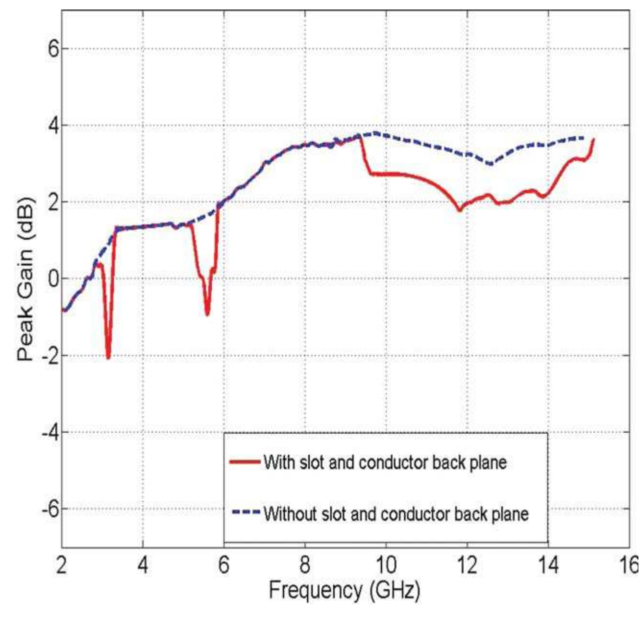

Figure 9 The peak gain of proposed antenna with and without filter. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

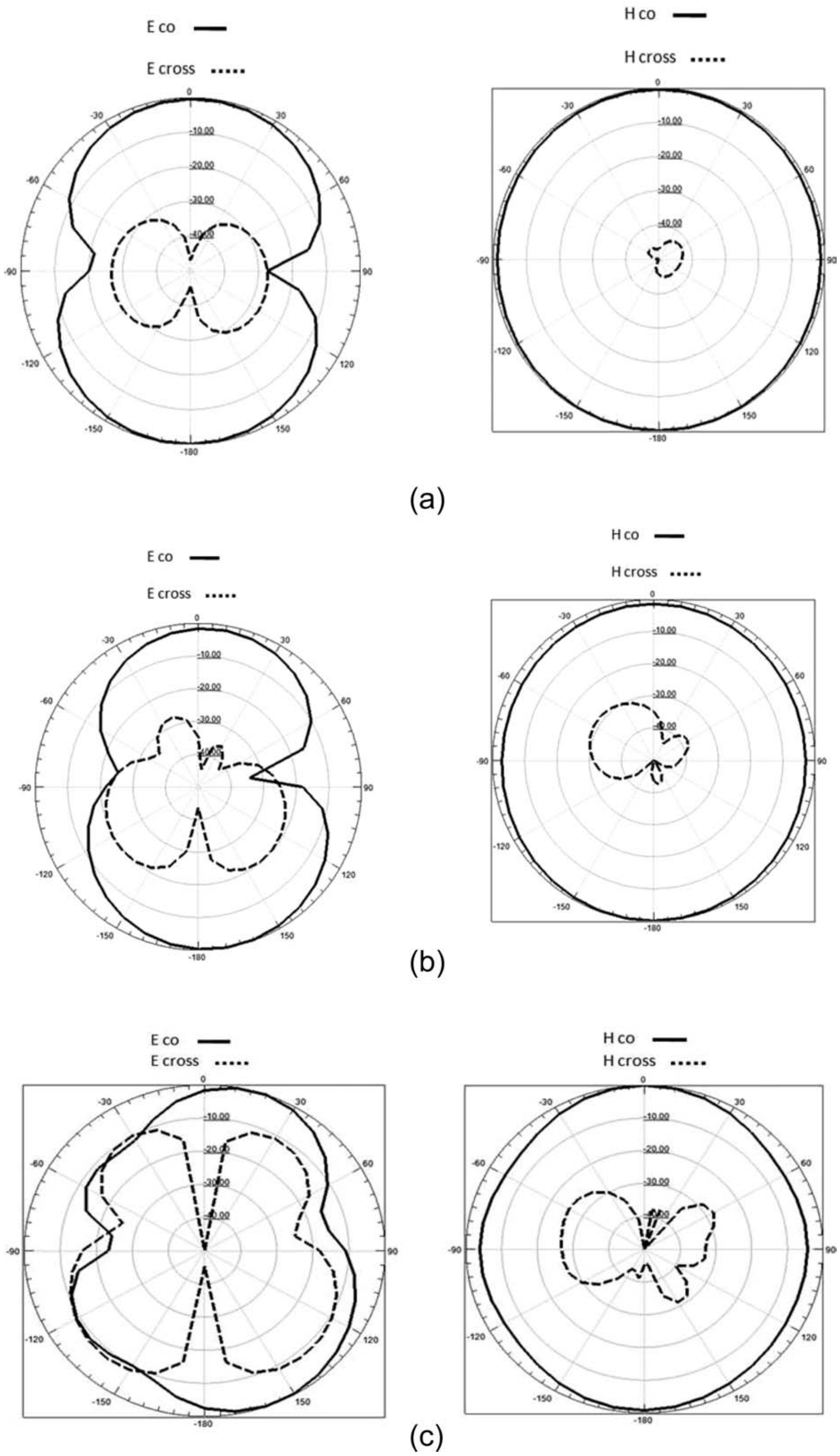

Figure 10 Fabricated *E*- and *H*-planes radiation patterns for 4, 7, and 10 GHz. (a) *E*-plane and *H*-plane radiation patterns for 4 GHz, (b) *E*-plane and *H*-plane radiation patterns for 7 GHz, and (c) *E*-plane and *H*-plane radiation patterns for 10 GHz

3. SIMULATION AND MEASUREMENT RESULTS

The proposed antenna with optimal geometrical parameters was obtained using Ansoft's high-frequency structure simulator (HFSS) and CST Microwave studio, and fabricated antenna's performance was measured using Agilent's Network Analyzer E8361c.

We obtained the same results in simulation with HFSS and CST softwares, but the results in this article are based on HFSS software.

It is clearly seen that the monopole antenna with a microstrip feeder exhibits a broad impedance bandwidth (2.7–14.3 GHz) with return loss <10 dB. However, by inserting the two lozenge slots that are connected to each other on the hexagonal radiation patch, a notch band at 5.3 GHz is obtained. As illustrated in Figure 4, it is observed that the other band notch is for WiMAX by putting the conductor back plane. However, we mentioned that we should adjust the distance between conductor back plane and the lozenge slots to filter accurately the two bands for WiMAX and the WLAN systems, in the same bands. In this article, we succeed to reach this goal by adjusting the fabricated size.

We can obtain the band notch without steps between the feed line and radiation patch but it is caused by reducing the bandwidth especially in lower frequencies. So, we add the steps to the radiation patch to enhance the impedance bandwidth.

Figures 5 and 6 show the measured results compared to simulated results. Good agreements are obtained between the measured and simulation S_{11} and VSWR results.

The edge of ground plane was constructed by the diagonal lines in order to improve higher frequency of UWB band and is shown in Figure 7. By connecting the ground plane to the substrate edge, we can see a mismatch in the impedance bandwidth especially in higher frequencies.

So for covering the UWB frequencies and to increase the impedance band width, we truncate the ground plane from the side parts.

In Figure1(b), we see some of the steps in the truncated ground plane. These nonequaled steps were optimized to enhance the impedance bandwidth of the proposed antenna. So, we apply the different steps to extent more impedance matching and cover the high frequency up to 14.3 GHz. As it showed, the dimensions of step 1, step 2, step 3, and step 4 are 4.2×1 mm^2, 3.2×1.5 mm^2, 1.2×1 mm^2, and 0.4×1 mm^2, respectively.

Figure 9 shows the peak gain of the proposed antenna with and without conductor backed-plane and slots structure. As expected, the gain decreases sharply at the notched frequencies bands for the antenna with bands-notched filter compared to the same antenna without it.

The measured radiation patterns are shown in Figure 10(a–c). The far field radiation patterns in the *yz* plane (*E*-plane) radiation pattern and *xz* plane (*H*-plane) radiation pattern at three different frequencies of 4, 7, and 10 GHz for obtained microstrip-fed monopole antenna are shown. These patterns are observed to be almost stable and omnidirectional for operation over UWB frequencies.

3. CONCLUSIONS

A compact microstrip-fed planar UWB antenna using a hexagonal patch and truncated ground-plane structure and a conductor back plane is proposed and fabricated that operates over an UWB frequency range of 2.7–14.3 GHz with VSWR <2. The designed antenna has two stop bands of 3.15–3.87 GHz for WiMAX and 5–5.85 GHz for WLAN systems. The proposed antenna has a compact size of $18.4 \times 21.8 \times 1$ mm^3 and provides omnidirectional radiation pattern across the entire UWB bandwidth making it suitable for UWB applications and next generation communication systems.

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A CPW-FED ANNULAR SLOT-ANTENNA WITH AN L-SHAPED STRIP

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Received 11 March 2011

ABSTRACT: *A slot-ring with any type of asymmetry can support more than one mode. Based on this simple observation, a short coplanar waveguide (CPW)-fed annular slot-antenna backed by an L-shaped strip is investigated in this article. On one hand, the annular slot-ring with a backed L-shaped strip and without the shorted stub is enough to generate a circularly polarized (CP) wave. On the other hand, the annular slot-ring with a shorted stub and without the backed L-shaped strip is enough to yield a broadband operation. In this article, we integrate both types of asymmetry in an annular slot-ring. We can achieve 10 dB return loss bandwidth from 2.4 to 4.5 GHz. Within this wide band, a CP wave is observed at the 2.45 GHz band.* © 2011 Wiley Periodicals, Inc. Microwave Opt Technol Lett 53:2821–2827, 2011; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.26416

Key words: *annular slot antenna; circularly polarized*