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Ultra Wide Band Compact Antenna with Dual U- Shape Slots for Notch-Band Application

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Abstract

In this article, a compact ultra-wideband monopole antenna with notch band characteristic is presented. The proposed antenna has a notch-band for rejection of WiMAX frequency at 3.5GHz. Here, we show the ability of controlling the notch frequency with some changes in U-slot. The antenna has the bandwidth of 3.1-16 GHz with the notch at 3.2-3.8GHz with high rejection and VSWR of notch around 16. The prototype antenna based on monopole antenna with dual U-shape slots is fabricated. The antenna ground contains a T slot for matching. The antenna has Omni-directional pattern in E-plane and bi-directional pattern in H-plane. The antenna gain has altered from -8 to 5.9 dB at the range of 2–16 GHz, with an average gain of 4.2 dBi. The total size of the antenna is 12×18×1.6 mm^3. The multi U line controls the current distribution, while it can be replaced by pin diode for achieving reconfigurable structure.

Keywords: UWB, U-slot, Notch, Monopole Antenna.

1. INTRODUCTION

UWB systems have been used in the communication system, medical imaging, radio communication and biomedical systems because of their wide bandwidth and economic advantages [1]. Many researches have been done for UWB system and devices. Usually, it noticed to the FCC (Federal Communication Commission) which have been determined some limitation for UWB systems like the one frequency bandwidth of 3.1- 10.6 GHz for wireless communication and Spectral density of -41.3 dBm per MHz defined for UWB frequency band [2]. Monopole [3] and CPW antenna [4] are used For UWB antenna. Circular and elliptical monopole microstrip antennas with different grounds are the common structures for UWB and omnidirectional applications. Circular CPW patches and small ground antennas are also conventional structures for UWB application while they are utilized for increasing the impedance bandwidth of the antennas, too [5-6].

We should use the filter to reject unnecessary bands of the frequency spectrum to avoid the interference between the signal of UWB system and the other communication systems, such as local area network and WiMAX. However, because of the volume limitation and extra price of implementing the filter at the portable system we need more compact and low-cost systems. Therefore, it is desirable to design the antenna with rejections characteristic at these frequencies [7].

Band notching techniques can be used for multi-band antennas which produce lower frequencies by using thin shaped slot on the antenna surface. The different shapes of slots are used such as U-shape and T-shape and they are studied in many researches on CPW antennas as band-notched UWB antennas [8-9].

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Table 1. ***Geometry dimensions of antenna.***

Parameter	mm
a	18
b	12
c	2
d	7
e	11.9
f	8.5
g	8
h	7
i	1
j	0.5
k	4
l	3.5
m	2
n	5

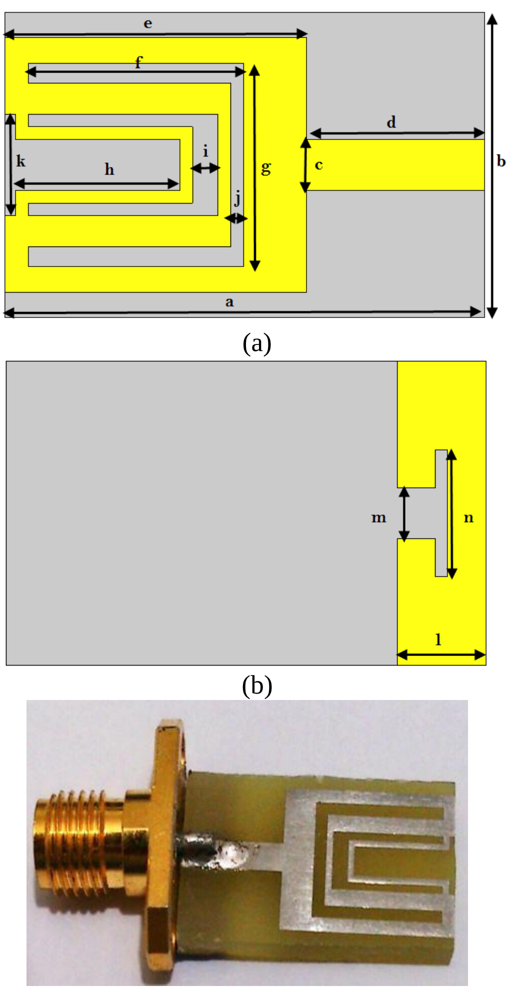

Fig. 1. The geometry of UWB antenna, (a) top view and, (b) bottom view of the antenna (c) the fabricated antenna

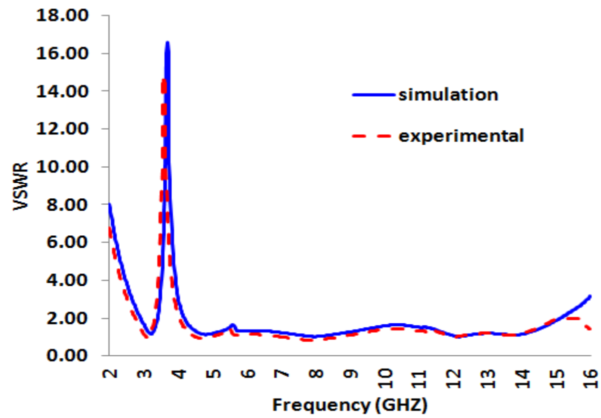

Fig.2. Simulation and experimental results of the VSWR.

Many monopole structures are developed by cutting an inverted Γ shaped slit with variabledimension on the ground plane [11], E-shaped SIR slot was inserted in the feed-line [12], a rotated Γ -shaped slot and G- shape patch [13], T-ring strips protruded inside square-ring radiating patch, a feed line, and a ground plane with a pair of rotated E-shaped slot [14].

The proposed antenna has a notch-band characteristic for rejection of WiMAX. The antenna has an Ultra wide bandwidth of 3.1-16 GHz with notches at 3.2-3.8 GHz Antenna is based on monopole antenna with dual U-shape slot for notch-band frequency. The antenna is fabricated and the results of the simulation are compared with experimental results while the experimental results confirm the simulation result for VSWR.. The U-shape arms provide wide bandwidth while the current distribution shows this effect.

2. ANTENNA DESIGN

The prototype antenna is based on monopole antenna with two U- shape slots. The antenna ground contains a combination of T slots. The prototype antenna is simulated with HFSS as a 3D full-wave electromagnetic field simulation tool and it is printed on a FR-4 low-cost substrate with relative permittivity of 4.4 and loss tangent of 0.02, with the thickness of 1.6 mm and a total dimension of $12\times18mm^2$. The antenna isa excited by a microstrip line with 2mm width, which

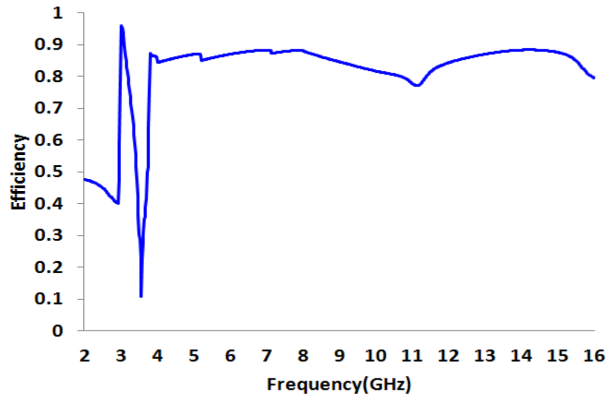

Fig. 3. The antenna efficiency (simulation result).

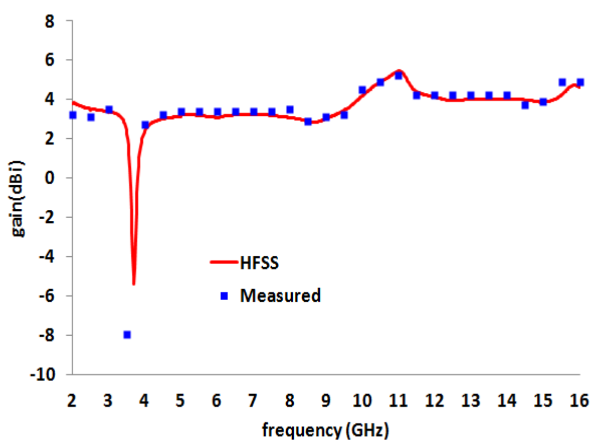

Fig. 4. The simulated and measured antenna gain.

provides 50 Ω input impedance. In the simulation, we have used an exact model of SMA connector. Fig.1 (a) and (b) show the antenna geometry with the top and bottom view, respectively, while Fig. 1(c) depicts the fabricated antenna. All dimensions of the antenna are presented in Table 1.

3. SIMULATION AND EXPERIMENTAL RESULTS

As shown in Fig.2, the antenna operates in 3.0-15GHz and 2.8-16GHz frequency range and in this bandwidth VSWR is less than 2 with one rejection band of 3.2-3.6 GHz to reject WiMAX frequency band. The VSWR is high to more than 16 at the rejection band. The results comparison between HFSS software simulation and the experimental results (with the HP8722ET network analyzer) is also presented.

In Fig.3, the efficiency of the proposed UWB antenna is shown, which is simulated by HFSS. The antenna efficiency reduced drastically at notch bands as shown. At the notch, the efficiency is around 10 % for 3.5 GHz and in other parts is more than 80%. The antenna's gain in the range of 2.1-12GHz is between 0 dBi and 4.5 dBi

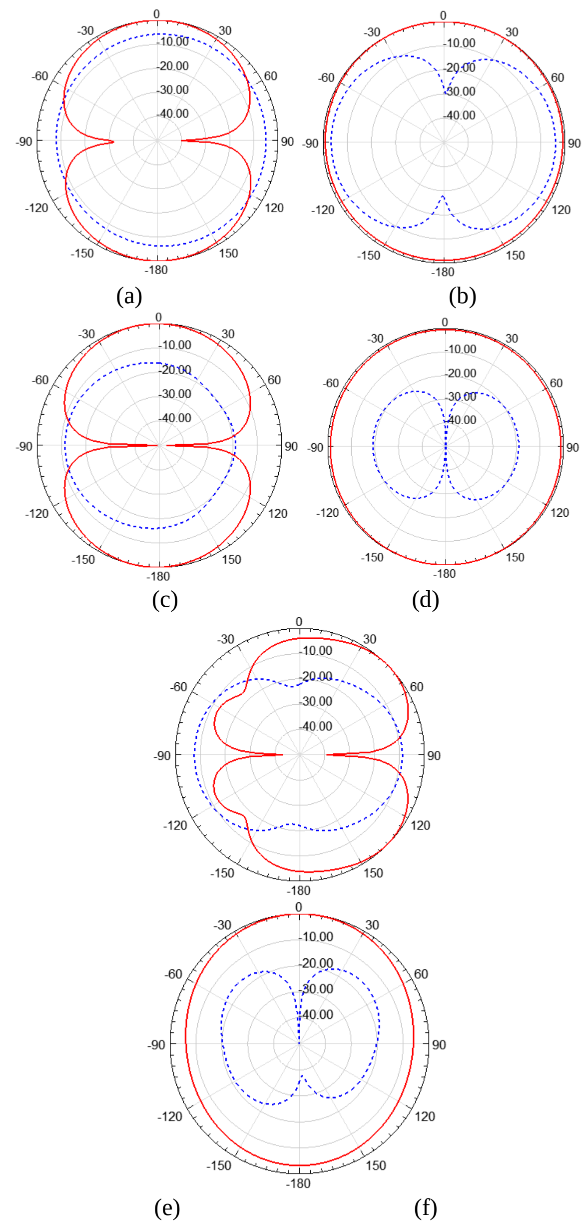

Fig. 5. Simulated radiation patterns of the proposed antenna (solid line for co-polarization and dash line for cross polarization), (a) E-plane at 2.8 GHz, (b) H-plane at 2.8 GHz, (c) E-plane at 6 GHz, (d) H-plane at 6 GHz, (e) E-plane at 10 GHz, (f) H-plane at 10 GHz

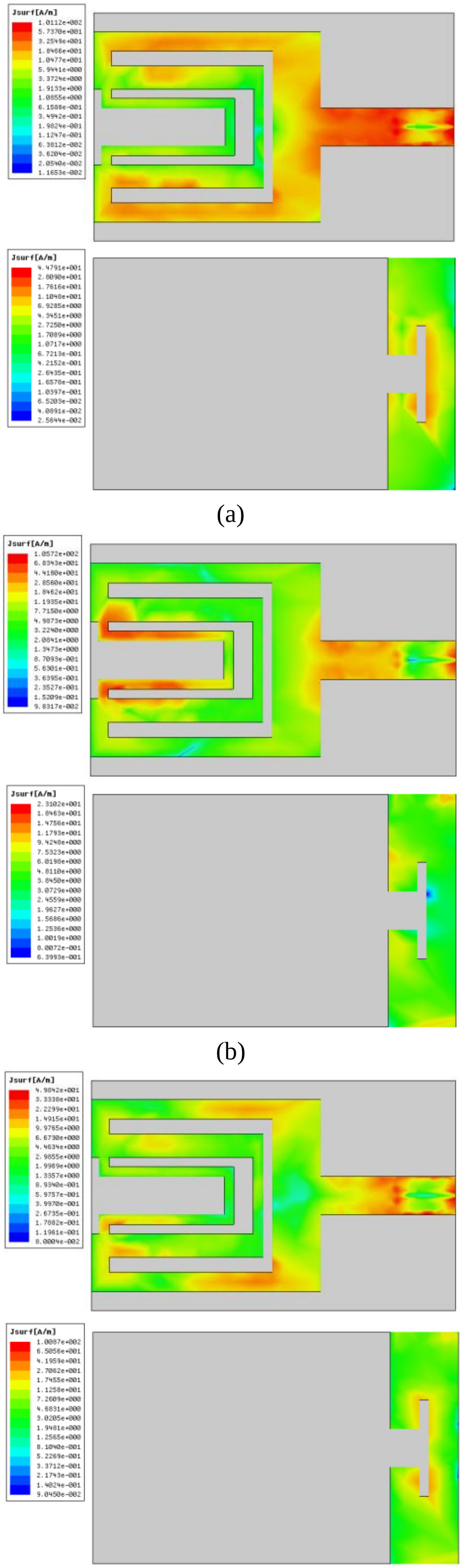

Fig. 6. The surface current distribution at (a) 2GHz, (b) 6 GHz, and (c) 10 GHz.

while the notch band's gain reduced to -10, as is shown in Fig.4 which also compares both simulated and measured results.

The simulated radiation patterns (co-polarization and cross-polarization) in E-plane (*y-z* plane) and H-plane (*x-z* plane) at 2.8, 6 and 10 GHz of the proposed antenna are shown in Fig. 5. The antenna radiates Omni-directionally in the E-plane and approximately bi-directionally in the H-plane.

Fig. 6 shows the surface current distribution simulations (by HFSS 11) for three frequencies of 2.8, 6, 10 GHz. The current for 2.8 GHz is shown in Fig. 6 (a) at the top and bottom part of the antenna which demonstrates that the maximum current concentrates in the top layer at the feed line. So, it shows that the SMA connector is an effective parameter at this frequency. In addition, the current has been distributed in all parts of the antenna's surface.

As shown in Fig.6 (b), at 6 GHz, the notch frequency, the current dispense on the surface of the antenna and it is limited to the feed part.. Finally, as depicted in Fig.6 (c), the surface current at 10 GHz is limited to the feeding section and a small part of the patch.

4. CONCLUSION

This paper proposed a monopole antenna with dual U-arm which can be considered for wide bandwidth within the range of 3.1-15 GHz with an effective notch band for WiMAX application at 3.5GHz. The surface current distribution shows the effect of the U-arm on the current while we can replace them with PIN diode to obtain the reconfigurable structure which cannot be achieved by the previous models such as the rectangular structure.

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