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# A NOVEL NOTCHED ULTRA WIDEBAND PATCH ANTENNA FOR MOBILE MICROCELLULAR NETWORK

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## ABSTRACT

In this article, we propose a radiating circular patch antenna with a partial ground plane, feed by a microstrip line, with a triangular shaped slots and one circular-ring-shaped slot in the radiating patch that can be deployed in mobile communication systems to avoid interferences with wireless local area network (WLAN) communication systems. Measured impedance bandwidth of the antenna is (0.89 GHz - 4.6 GHz), which covers GSM-900/1800/1900, UMTS 2.1 GHz (3G), UMTS 2.6 GHz (4G) and 3.5 GHz (WiMAX) for $S_{11}$ < -10 dB and also the proposed antenna have a single stop band from 2.4 GHz to 2.6 GHz for rejecting the WLAN IEEE 802.11 b/g/n frequency band. The studied antenna design, analysis and characterization has been performed using a commercially available electromagnetic solver based on finite elements. The antenna prototype was developed and realized on a FR4_epoxy substrate with a thickness of 1.58 mm, and a size of 160 x 110 mm$^2$. Reflection coefficient and directivity results were measured, presented and discussed.

**Keywords:** GSM, 3G, 4G, WiMAX, microcell, microstrip antenna, band notched, UWB.

## INTRODUCTION

The growing needs of modern day communications mean that simple antennas cannot cover all of our needs, and further, it may cause that many systems operate across several frequency bands, the solution to this matter is to design antennas that have UWB effect and with band notch characteristics to avoid potential interference from the other frequency bands.

To improve the coexistence of UWB systems with other wireless standards, a considerable amount of research has been devoted to devising techniques to reject certain bands within the passband of the UWB. The common ways to introduce the additional resonant structure include etching slots or slits on the antenna metal plate, placing parasitic strips in close proximity to the radiating element, and applying folded strips. Some UWB antennas have been reported in the literature, but most are rather large. Some researchers have focused only on the compact size of UWB. Because there is no attention paid to the band rejection in WLAN application, interference will affect the frequency range for UWB systems with the existing wireless communication systems. Some researchers presented a UWB antenna with a rejection band or band notch in the 5 GHz to 6 GHz frequency range by using an insertion strip or slot in the antenna.

A reported UWB antenna was designed by embedding a U-shaped parasitic strip and a pair of T-shaped stubs in wide slots to obtain dual-band stops around 3.5 GHz and 5.5 GHz. An UWB antenna has been designed with a dual band-notch for WLAN that covers the frequency ranges of 5.09 GHz to 5.36 GHz and 5.72 GHz to 5.825 GHz. Also the authors presented a novel dual band-notched monopole antenna at 3.5 GHz (WiMAX) and 5.5 GHz (WLAN); however, the results do not show the shifted band-notched frequency with enhanced Bandwidth (BW) of the band notch. Moreover, the geometry of this antenna is relatively complex.

In this research paper, we propose a circular slot microcell antenna with a partial ground plane for UWB applications. By inserting a simple parasitic insertion strip (two types: ring-shaped and triangular-shaped), single band-notched characteristics from 2.44 GHz to 2.66 GHz can be easily obtained to reduce the potential interference between the UWB system and Indoor communication like the WLAN (Wi-Fi) systems.

## ANTENNA DESIGN

Figure 1 illustrates the schematic of the proposed antenna. The basic antenna (antenna a) is a circular patch which was the subject of a number of changes to cut the frequency band 2.4 GHz reserved for the Wi-Fi/WLAN systems. The proposed antenna (antenna c) consists of a circular radiating patch with slots and a partial ground plane is printed on the bottom surface of the substrate.

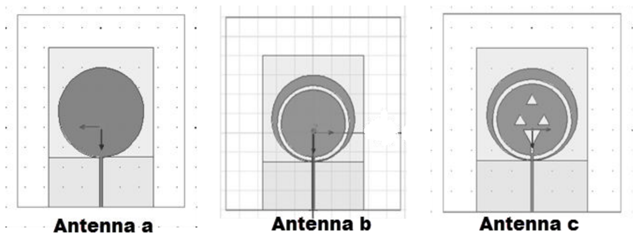


**Figure-1.** Schematic of the proposed antenna.

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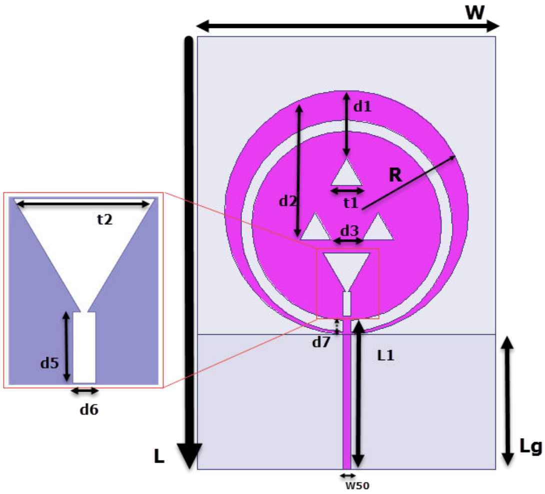


**Figure-2.** Geometry of the proposed antenna (antenna c).

**Table-1.** The optimal dimensions of the suggested antenna (antenna c).

| Elements | Dimensions |
|---|---|
| FR4 Substrate<br>Circular Patch | L=160 mm; W= 110 mm<br>R = 45 mm |
| Microstrip line | $W_{50}$ = 3 mm; $L_1$ = 54 mm |
| Ground plane | W = 18 mm; $L_G$ = 60 mm |
| Slots | $d_1$ = 25 mm ; $d_2$ = 53 mm |
| | $t_1$ = 11.5 mm |
| | $d_7$ = 4 mm |
| | $t_2$ = 17 mm |
| | $d_5$ x $d_6$ = 9 mm x 2.8 mm |
| | |

Figure-2 shows the geometry of the antenna studied. The antenna is simulated on a FR4_epoxy substrate of 160 x 170 mm2 with a dielectric constant εr = 4.4. The thickness of the substrate is 1.58 mm. A circular patch including slots with their different sizes are shown in Table 1, The patch has four slots in the form of triangles equilateral, and the antenna feeding is performed by microstrip line in order to adapt to 50Ω.

## RESULTS AND DISCUSSIONS

Figure-3 illustrates the simulation of the $s_{11}$ parameter of the circular antenna (antenna a), feed by a microstrip line on a substrate EPOXY_FR4 with h = 1.58 mm and a partial ground plane.

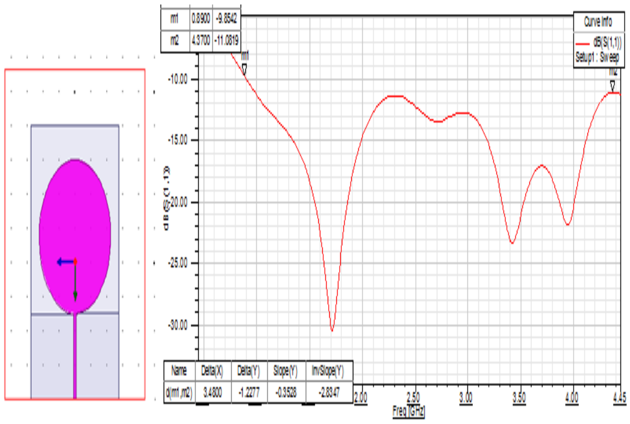

**Figure-3.** Reflection coefficient vs frequency (antenna a).

We can notice the existence of an ultra-wideband effect in the frequency band (860 MHz - 4.6 GHz).

Figure-4 shows the addition of a notch in the form of an asymmetric ring that'll allow the elimination of the band WLAN IEEE 802.11 b / g / n (2.4 GHz - 2.484 GHz). The relation between central notched frequency and the length of the notch can be determined approximately based on this equation:

$$L_{notch}(mm) = \frac{\lambda_d}{2} = \frac{c}{2f_{notch}\sqrt{\varepsilon_r}}$$

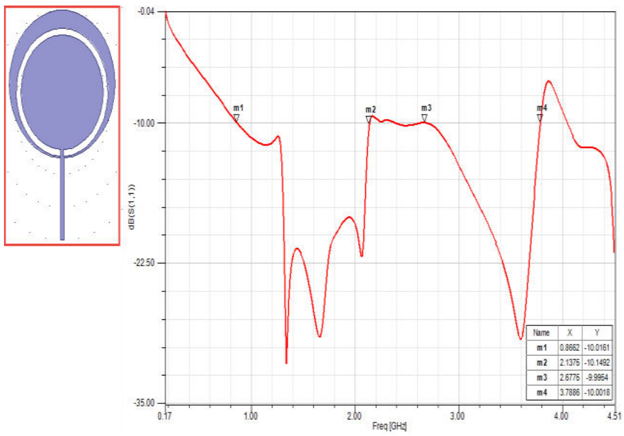

**Figure-4.** Reflection coefficient vs frequency (antenna b).

We can notice the existence of two frequency bands (860 MHz-2.2GHz & 2.7GHz- 3.8 GHz).

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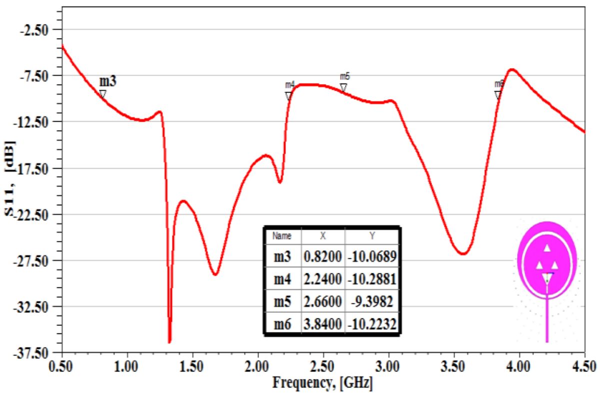


**Figure-5.** Measured $S_{11}$ against frequency (antenna c).

**Figure-6.** The realized antenna (antenna c).

In Figure-5 we see that the introduction of triangular apertures can optimize dramatically the S11 parameter of the antenna, so we can cover the frequency band of 2.6 GHz (UMTS 4G).

We illustrate in Figure. 6 the radiation pattern in 3D at five frequencies 0.9 GHz and resonant frequencies 1.8, 2.1, 2.6, 3.5 GHz.

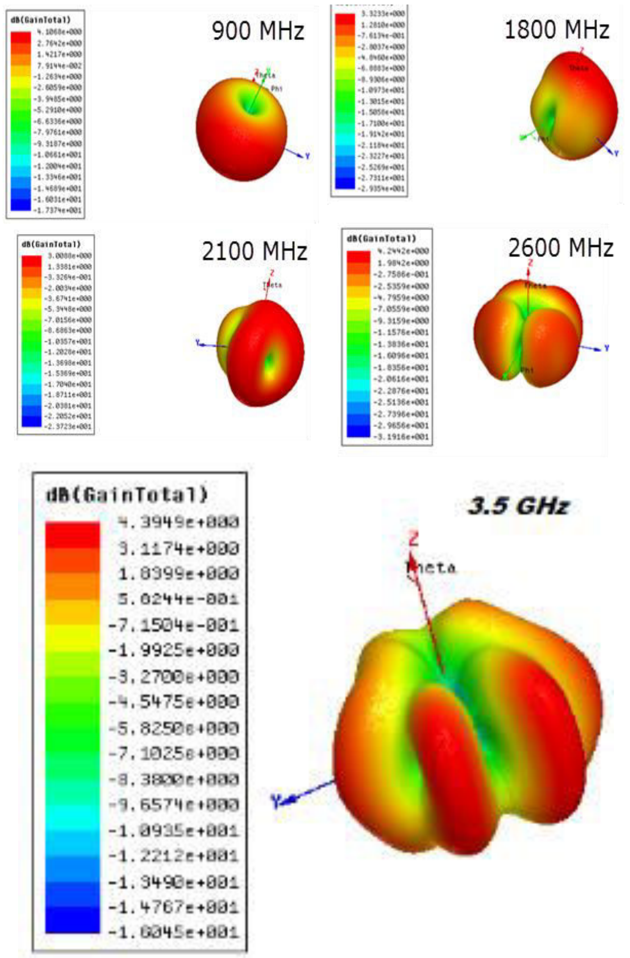


**Figure-7.** Simulated gain of the realized antenna.

Figure [8-10] shows the 2D simulated radiation patterns of the proposed antenna at 900 MHz, 1800 MHz, 2100 MHz, 2600 MHz, and 3500 MHz respectively.

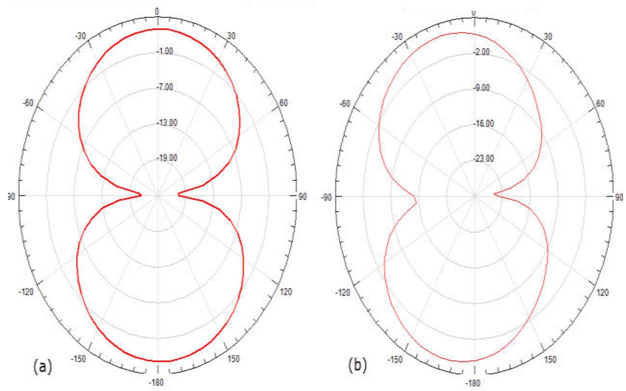


**Figure-8.** 2D Radiating patterns at frequency 900 MHz (a) and 1800 MHz (b).

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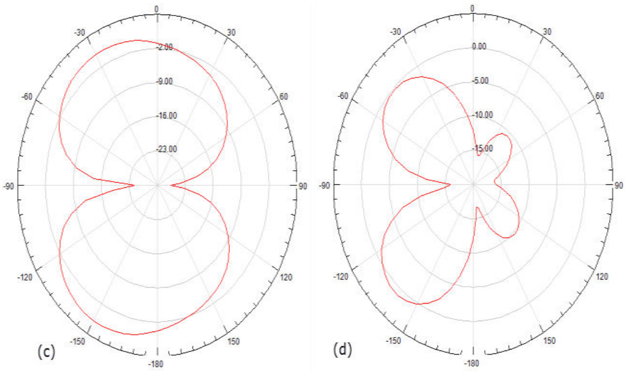


**Figure-9.** 2D Radiating patterns at frequency 2100 MHz (c) and 2600 MHz (d).

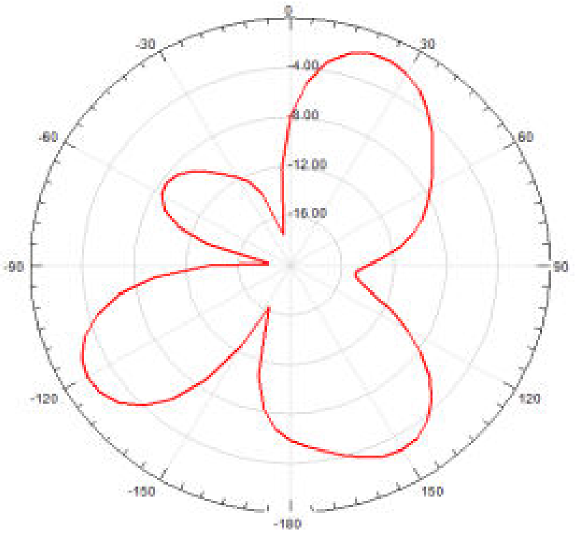


**Figure-10.** 2D Radiating patterns at frequency 3500 MHz.

## CONCLUSIONS

This antenna covered the frequency spectrum 860 MHz-2.2GHz and 2.7GHz-3.8 GHz with sufficient bandwidths for mobile communication systems. We have demonstrated in this study that the use of a partial ground plane could have a significant impact on the bandwidth of the antenna. The proposed microcell antenna is simple to design and compact in size. It provides broadband impedance matching, consistent omnidirectional radiation patterns and appropriate gain characteristics in the GSM/3G/4G/Wi-Max frequency region. The antenna has been designed on a typical FR4 substrate and realized with conventional Printed Circuit Board (PCB) techniques.

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