Planar UWB Fractal Antenna with Band-Notched Characteristics

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***Abstract*—A simple and compact coplanar waveguide (CPW)-fed ultra wideband is presented. The proposed antenna consists of a circular patch with triangular slot, which is etched onto FR4 printed circuit board (PCB) with overall size of $39.2 \times 43.5 \times 1.6mm^3$. The simulated and measurement results shows that the antenna achieves good impedance matching, consistent gain, stable radiation patterns and consistent group delay over an operating bandwidth. Extended UWB antenna with notch band (3.3-3.6GHz & 5-6GHz) design are also presented as a desirable feature for UWB application.**

***Index Terms*—CPW-fed UWB antennas, band-notched characteristics,Group delay.**

I. Introduction

Ever since the Federal Communication Commission (FCC) released the commercial operation of UWB within the range 3.1-10.6GHz, the design of UWB antenna has attracted considerable interest in both the academic society and the wireless industry community. However, there still exist several narrow band for other communication systems over the designated frequency band, such as: the wireless local area network (WLAN) for IEEE 802.11a operating at 5.15-5.35 GHz and 5.725-5.825GHz and IEEE 802.16 WiMAX system operating at 3.3-3.6GHz,which may cause severe electromagnetic interference to the UWB system. Therefore, it is desirable to design UWB antennas with band-notched performance in those frequency bands to avoid potential interference.

Several studies on printed wide-slot antennas indicated that the impedance bandwidth of the antenna is controlled by the coupling between the tuning stub and the slot. Bandwidth enhancement is achieved by employing a feeding scheme that generates multiple resonances. Then, by optimizing the distance between the tuning stub and ground surrounding it, the impedance changes from one resonant mode to the other is minimized, resulting in wideband operation. Fork-like, circular, elliptical rectangular and inverted cone shapes of the tuning stubs have been reported [1], [2] In this paper[3], the self-similarity property of the fractal technology is used to construct the multifrequecy antenna structure to realize the UWB characteristic under the standard mask set by FCC. And the space filling property of the fractal technology is used to reduce the size of the UWB antenna[4], [5], [6], [7].

II. UWB Antenna Design

A CPW fed circular disc monopole antenna for UWB application was designed by Min Ding et al. Proposed three antenna structures are shown in Fig.1 the original structure of the UWB fractal antenna and its first and second order iteration structures. Fig. 2 shows that simulated result different iteration of VSWR vs Frequency curve. Fig.3 shows the geometry and configuration of the UWB antenna, which is printed on a substrate with size of 39.2×43.5mm^2, thickness of 1.6mm,and relative permittivity of 4.4. The width of the microstrip feed line is fixed at 1.36mm to achieve 50Ω characteristic impedance. The electromagnetic software CST Microwave Studio is employed to perform the design and optimization process. The final parameters are $D_1 = 25mm$,$D_2 = 12.5mm$,$D_3 = 6.25mm$,$L = 18.6mm$,$H = 15.5mm$,$W = 1.36mm$. The measurement of VSWR was carried out with a network analyzer Agilent E8363B. Fig.4

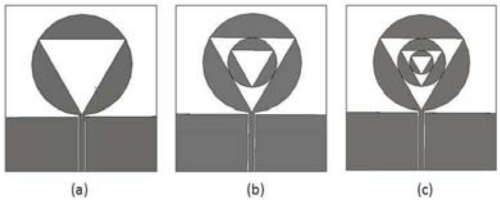

Fig. 1. Geometries of the CPW-fed ultrawideband fractral antennas (a) original structure, (b) first order iteration, (c) second order iteration.

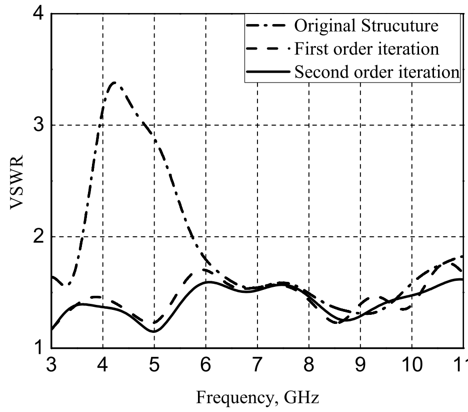

Fig. 2. Simulated VSWR of three different strucures.

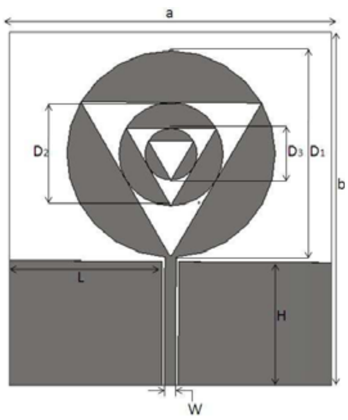

Fig. 3. Geometry and configuration of antenna 1.

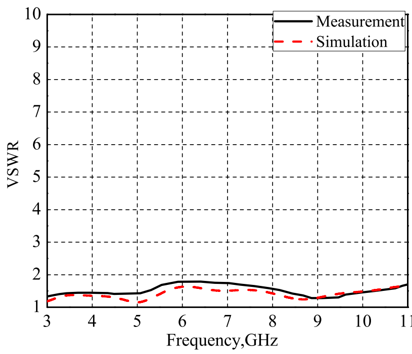

Fig. 4. Measured and simulated VSWR of antenna 1 with optimal dimentions.

shows the characteristics of the measurement and simulated VSWR of antenna 1. A relatively good agreement in between measurement and simulation has been observed.

III. BAND-NOTCH ANTENNA DESIGN

A. Single Band-Notched UWB Antenna Design and Results:

To reduce the interference from the IEEE802.11a and HIPERLAN/2 WLAN systems, the band-notched function is desirable in the UWB systems. Fig.5. shows the geometry and dimensions of the UWB antenna with filtering property operation in the 5-6GHz band (antenna 2). By etching a L-shaped slot in the ground of antenna 1, a frequency band notch is created. Note that when the band notched design applied to antenna 1, there is no retuning work required for the previously determined dimensions.The final design parameters of the L-shaped slot are $L_1 = 05mm, L_2 = 9.5mm,$

B. Double Band-Notch UWB Antenna Design and Results:

Performance of the simulated VSWR of antenna 2 is shown Fig.6. From the figure, it is evident that the desired filtering property is introduced by the L-shaped slot as expected. Compare to antenna 1 design, the single band notched UWB antenna successfully blocks out the 5-6GHz band and still performs good impedance -matching at other frequency in the UWB band. The antenna gain in the UWB band is presented in Fig.7. Which shows a sharp gain decrease in the 5-6GHz band and good performance at other frequencies in the UWB band.

Fig.8 shows the geometry and dimensions Double band notch of these desing are presented. The final parameters are $L_1 = 20mm, L_2 = 30mm, L_3 = 7mm, , W_1 = 1mm.$ The hook-shaped slits design inserted above the patch. In general, the design concept of the Band notch function is to adjust the total length of the slits to be approximately half-wavelength at the desired notched frequency, which makes the input impedance singular at the sub-resonant frequency. To implement it, a narrow-band resonant structure is added to the original wide-band antenna area. Based on this concept, the above two designs using L and hook shaped slits as illustrated.Performances of the simulated and measurement VSWR two kinds of band notch antennas are shown in Fig.9.Compared to UWB antenna the dual band notch UWB

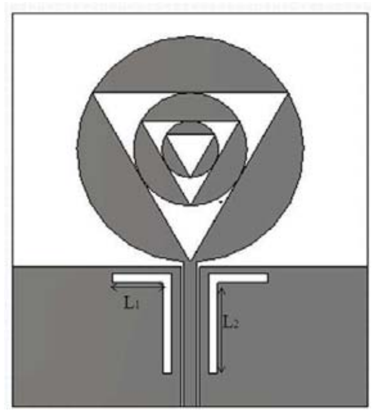

Fig. 5. Geometry of the proposed antenna with Notched bands.

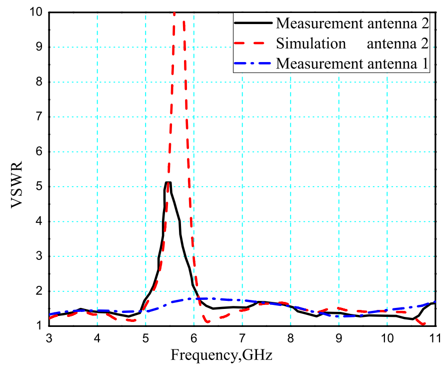

Fig. 6. Measurement and Simulated VSWR of antenna 2, compared to antenna 1.

successfully blocks out the 3.3-3.6GHz and 5-6GHz frquency band and still performs good impedance matching at other frequencies in the UWB band. Fig.10 Shows current distribution at frequency 3.5&5.5GHz. At 3.5GHz the current distribution mainly flow along the transmission line, while around the L-shaped slot the current is small. At 5.5GHz as shown in Fig.10.(b), the current distribution flows around the hook shape slot. In this case, impedance mismatch occurs, which causes the antenna to be non-responsive at the frequency.

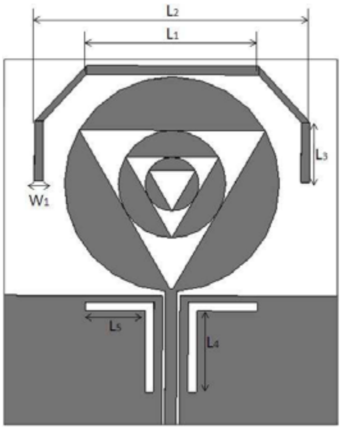

Fig. 7. Geometry of the proposed antenna 3 with Double Notched bands.

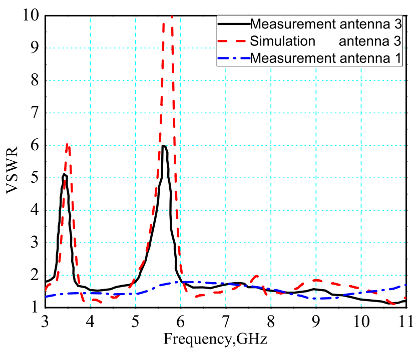

Fig. 8. Measured and simulated VSWR of antenna 3, Compared to antenna 1.

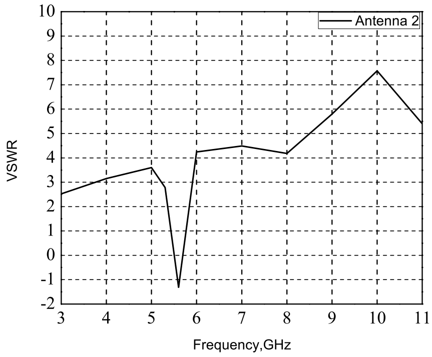

Fig. 9. Simulated gain of antenna 2

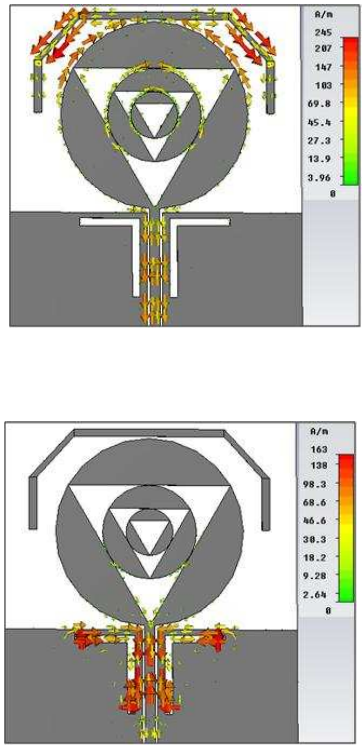

Fig. 10. Simulated current distribution at different frequencies (a)3.5GHz (b)5.5GHz.

The simulated far-field radiation patterns of the proposed antenna at sampling frequency of 4.5GHz and 8GHz are investigated in Fig.5. The proposed antenna has monopole like patterns in the E-Plane and nearly omnidirectional radiation patterns in the H-Plane [8], [9] . The antenna gain in the entire UWB band is presented in Fig.11. It shows a sharp gain decreases at 3.3-3.6GHz and 5-6GHz band, good performance at other frequency in the UWB band.

In UWB application, to minimize the potential interference between the UWB system and the narrowband systems, the variations of the transfer function magnitude and the group delay should be as acute as possible in the notch-bands and need to be constant in the un-notched bands[10], [11], [12], [13], [14], [15], [16], [17]. The group delay of magnitude transfer function is simulated between two identical antennas in the face-to-face orientations,with a distance 0.6m between them. The simulated magnitude of the transfer function and gruop delay of the antenna are presented in Fig.13. Sharp decrease in the magnitude of the transfer function are shown in the notched frequency bands.

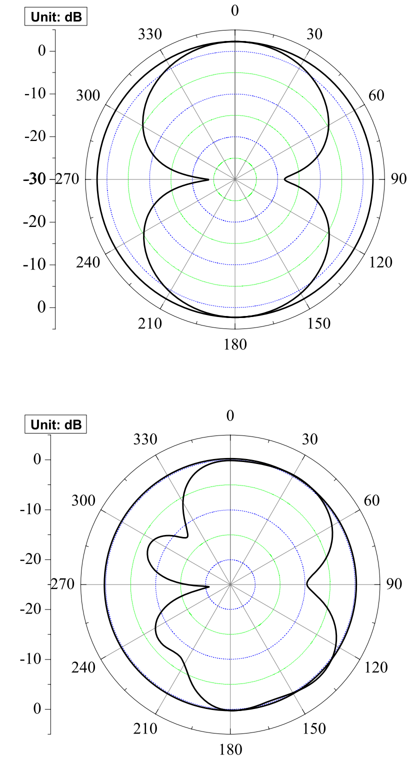

Fig. 11. The simulated radiation patterns at 4.5 and 8GHz(a)y-z plane(H-plane) (b)x-z plane (E-plane).

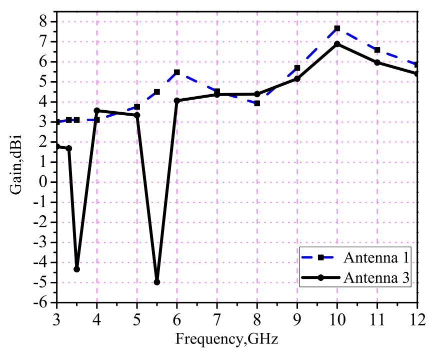

Fig. 12. Simulated Gain Vs Frequency characteristics.

IV. Conclusion

The compact UWB antenna and band-notch characterized has been presented and implemented successfully by Fractral technology in this paper. The simulation and measurement results of proposed antennas shows a good agreement in terms of the VSWR, antenna gain and radiation patterns. Therefore, the antenna is attractive for UWB application.

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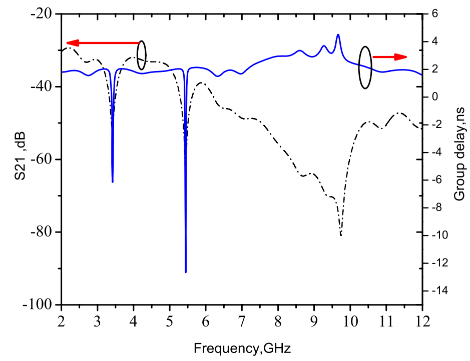

Fig. 13. Magnitude of transfer function and group delay of the proposed antenna 3 with notched bands in two Tx/Rx setups.

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