# Compact Reconfigurable Band Notched UWB Cylindrical Dielectric Resonator Antenna Using Single Varactor Diode

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## Abstract

This paper presents compact UWB cylindrical dielectric resonator antenna with reconfigurable band notch capability using single varactor diode. Theoretical results are achieved for the design with the range of frequencies 4-10.6 GHz. Using single varactor diode, different notch frequencies can be obtained using different capacitance values. The effect of changing the varactor position is also examined. A Wide range of notch frequencies can be achieved using this simple configuration, which covers most of coexisted narrow band systems. The notch frequency can be lower by increasing the capacitance value. Finite Element Method (FEM) and Finite Integration Technique (FIT) are hired to simulate the proposed antenna structure using HFSS and CST MWS respectively. The notch frequency covers the WLAN band when C =0.9 pF and covers the WiMAX band when the capacitance is changed to 0.8 pF for the same antenna configuration and varactor position. The antenna with DRA has a directive radiation pattern in E-plane and omnidirectional pattern in H-plane. Also, the gain is suppressed in the notched frequency. The group delay is nearly stable in the UWB frequency range, except at the notch frequencies

**Keywords:** Band notch frequency, FEM, DRA, HFSS, micro strip, UWB, planar monopole antenna, Tunable, Numerical technique.

## 1. Introduction

Due to Federal Communications Commission (FCC) defined UWB between 3.1 - 10.6 GHz with a band width of 7.5GHz [1]. Hence, researchers have attracted for ultra-wide band radio technology due to its advantages such as high-speed data rate, low cost, small size, and more secure [2]. Planner monopole antenna is characterized by low cost, ease of fabrication, low profile, wide bandwidth, and high radiation efficiency so that it is one of the most common UWB antennas [3]. A narrow band system as WLAN, WiMAX, and X-band are coexisted in the same UWB frequency band. Recently a lot of UWB monopole antennas with single or multiple notch frequencies to avoid this interference have been introduced. The band notch characteristics can be achieved through; various slots in radiating patch [4-7], slots in feed line [8-10], slots in the ground plane [11-13], and parasitic patches [14]. The wide range and UWB features achieved by the dielectric resonator antennas (DRAs) make them potential candidates for UWB systems [15]. Several UWB DRAs with a band-stop performance have been proposed. Dielectric resonator antennas (DRAs) have several features, including low dissipation loss, high radiation efficiency, various excitation mechanisms, different DR shapes, nearly constant gain, and compact antenna size [16]. It has more shapes such as cylindrical [17], rectangular [18], hemispherical [19], and cylindrical ring [20]. However, these antennas have fixed band notch characteristics and in cases where there is no interference, they are unable to utilize the all over UWB frequency range. Hence, using reconfigurable band notch structure can improve the performance of the UWB system. In reconfigurable band notch UWB antennas, changing the notch frequency is achieved by using lumped elements such as PIN diodes or varactor diodes [21-22].

Our goal in this paper, to achieve a simple reconfigurable band notch UWB antenna using cylindrical DRA. A slot is made on feed line to be loaded by single varactor diode. A wide range of frequency band-notches, which cover almost all the narrow band coexistence systems, can be obtained simply by changing the capacitance value and position. A variable capacitor or a varactor diode instead of using single capacitor element can do reconfiguration. Finite element method (FEM) in the frequency domain and finite integration technique (FIT) in the time domain are used to simulate the proposed structures using Ansys HFSS [23] and CST MWS [24], respectively. The proposed antenna with a directive radiation pattern in E-plane and omnidirectional pattern in H-plane. Also, the gain is suppressed in the notched frequencies. The group delay is the almost flat response is noticed over the operating bandwidth, which indicated very little distortion sharply in the notch frequency. These results suggest that the proposed antenna will be useful widely in UWB applications.

## 3. Antenna design

The proposed cylindrical DRA monopole antenna structure is shown in Fig. 1. The antenna is printed on an RO3003 dielectric substrate having a thickness of 0.75 mm with a relative permittivity of 3. Where the total size of the antenna is $W_a$, $L_a$. The ground plane which is on the back side with $W_a$, L width and length respectively. Cylindrical DRA with radius R and height h. Rectangular slot with length S is made in the micro strip line to fit a varactor diode. An SMV2019-040LF varactor from 0.3 pF to 1.4 pF depending on the applied reverse DC voltage. The varactor has two different positions as shown in Fig. 1. All this parameter shows in table1.

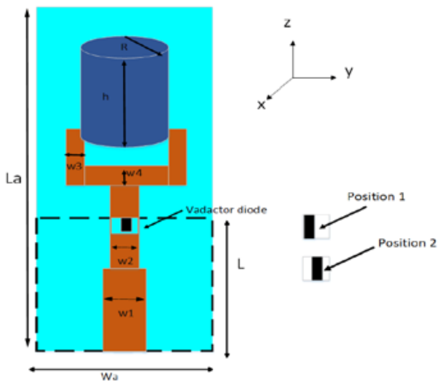


Figure 1: cylindrical DRA shaped UWB planar monopole antenna loaded by a single varactor diode.

Table 1: The design parameters of the proposed antenna

| Design parameters | Dimensions in (mm) |
|---|---|
| $W_a$ | 12 |
| $L_a$ | 30 |
| $w_1$ | 1.95 |
| $w_2$ | 1.7 |
| $R$ | 3.6 |
| $S$ | 1.5 |
| $H$ | 10 |
| $w_3$ | 1.3 |
| $w_4$ | 1.1 |
| $L$ | 9.5 |

## 2. Results and discussion

In the beginning, the cylindrical DRA shape is optimized to achieve UWB characteristic the reflection coefficient is examined. Figure 2 shows the reflection coefficient $S_{11}$ with different $E_r$. As $E_r$ decreases, the antenna has wide band width and a null is found between 4 and 9 GHz. At $E_r$ =13 the antenna set the UWB characteristics and has a continuous bandwidth between 4 and 10.6 GHz. Figure 3 demonstrates the effect of dielectric length on the reflection coefficient. As shown in fig3. decreasing the dielectric length, increasing the antenna band width beyond 11GHz. Figure 4 illustrates the effect of dielectric radius on reflection coefficient. It is clear that when R = 3.6mm this achieving UWB characteristic. Figure5 demonstrates the effect of ground length on the reflection coefficient. It is clear that when L= 9.5mm this achieving UWB characteristic. A single varactor diode is loaded in the slot. The varactor position is changed two times as shown in Fig. 5 In each position, the capacitance is changed and the corresponding reflection coefficient is stored. Figures 6-7 show the return loss versus frequency for the different capacitance values and position. In each position increasing the capacitance value, decreasing the notch frequency. A wide range of notch frequencies can be obtained using this simple configuration, which covers most of the narrow band coexistence systems. For example, as shown in Figure 5 the notch frequency covers the WLAN band when C=0.8 pF. CST and HFSS are used and their results are shown in Fig. 8. Very good agreement is obtained between both results

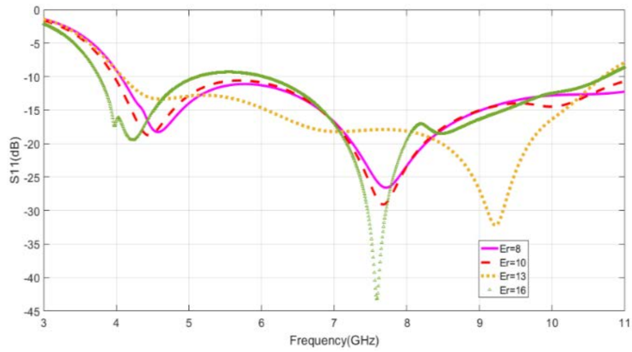


Figure2: Simulated $S_{11}$ characteristics of the proposed UWB cylindrical DRA monopole antenna without slots for different E

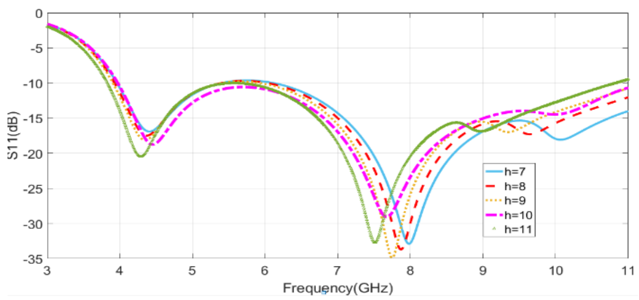


Figure3: Simulated reflection coefficient for various length of DRA h.

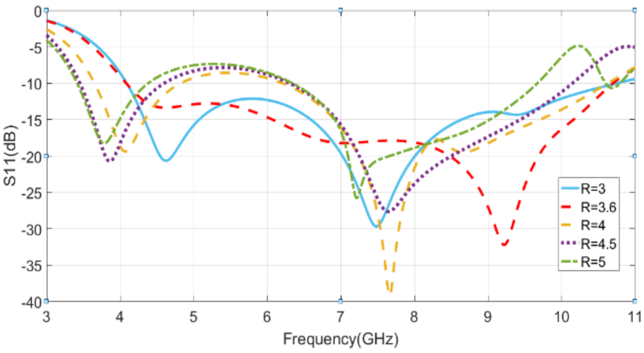


Figure4: Simulated reflection coefficient for various radius of DRA

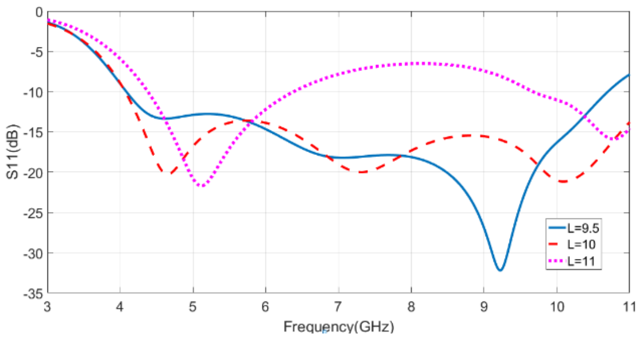


Figure5: Simulated reflection coefficient for various length of ground L.

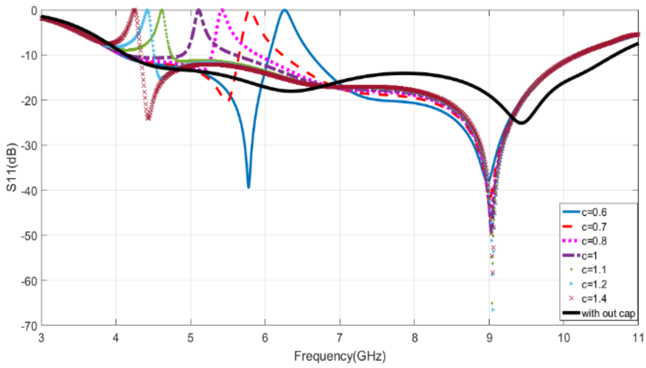


Figure 6: $S_{11}$ characteristics of the proposed antenna for different capacitance values in position one

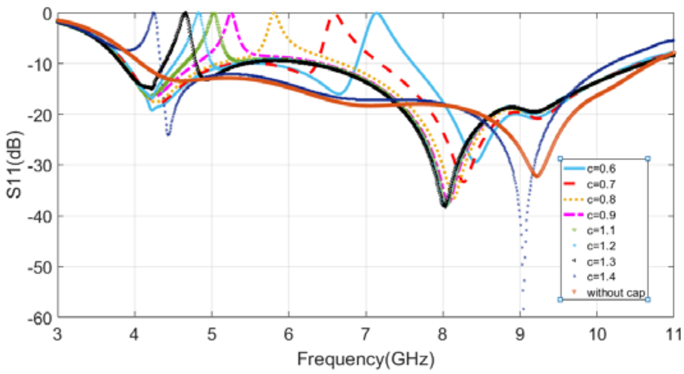


Figure 7: $S_{11}$ characteristics of the proposed antenna for different capacitance values in position two

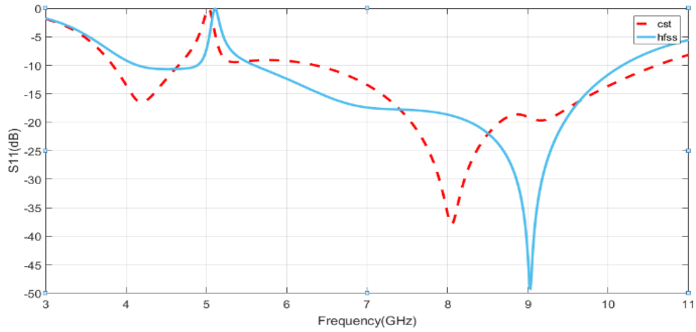


Figure8: The simulated S11 of the proposed antenna with c=1pf using CST and HFSS

## 3. THE RADIATIONS PATTERNS, GAIN, and GROUP DELAY

In this section, the radiation pattern gains, and group delay for the Previously stated cases will be achieved. Figure 9 shows the different radiation pattern at different frequencies 4,6,10 GHz for the proposed antenna with capacitors elements. From figure, it's clear the pattern is directive in the E-plane and omnidirectional in H-plane. The gain is shown in fig.10. AS shown in figure, the gain is suppressed in the notched frequencies at5.2GHz for given capacitor value. The group delay is shown in Figure 11. The group delay has very little variations across the operating band within a range of 1 ns, but at the notch frequency, the group delay has very sharp changes.

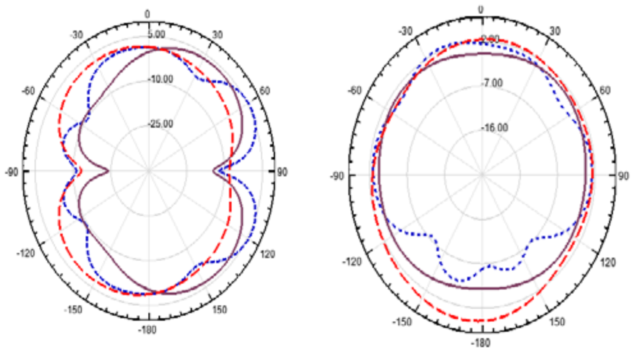

Figure 9: The Radiation patterns of the UWB antenna cylindrical DRA with capacitor elements. C=1 pF [4 GHz (Red-long dashes), 6 GHz (Blue-short dases), 10 GHz (brown -solid)]

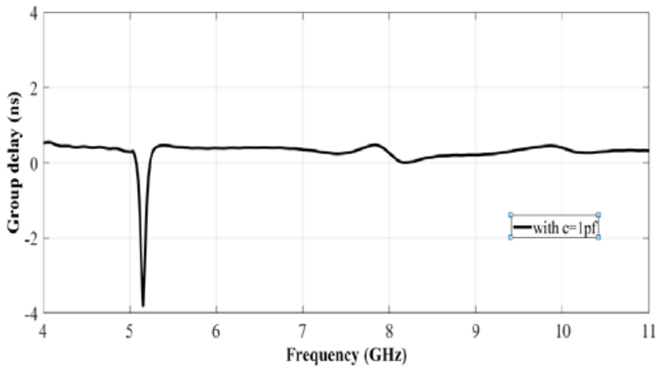


Figure 10: The proposed antenna gain versus frequency.

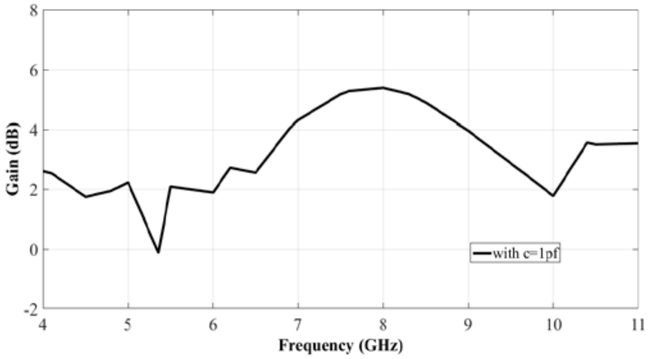


Figure 11: The group delay.

## 4. Conclusion

In t his paper, ul tra-wide band a ntenna w ith s ingle ba nd notched characteristics has been proposed and analyzed. The UWB antenna is examined on substrate RO3003 with relative permittivity of 3 and has cylindrical DRA radiation patch. Different notch frequencies can be obtained through make a rectangular slot on micro strip and loaded by varactor to achieve tunable notch frequencies. A wide range of notch frequencies can be obtained using this simple configuration, which covers most of the narrow band coexistence systems. The effect of the capacitance v alue o f t he v aractor d iode o n t he n otch f requency i s investigated. FEM is used to simulate the proposed antenna structure using ANSYS HFSS. The notch frequency covers the WLAN band when C= (0.8-1) pf. The proposed antenna yields a directive radiation pattern in the E-plane omnidirectional the pattern in H-plane. Also, the gain is suppressed in the notch frequency

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