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Wideband Notched Rectangular DRA

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Abstract: ***In this work,*** **a** ***wideband notched rectangular DRA is presented. The proposed antenna is placed on a rectangular ground plane and four notches of equal size and equally spaced are grooved at the bottom before excited by a probe to give a wide 10-dB impedance bandwidth of 37.8% between 2.25GHz and 3.3GHz. The antenna has an average gain of 4.45dBi with broadside radiation pattern as expected. HFSS2014 is main tool used in this study.***

Keywords: Dielectric Resonator Antenna (DRA)**,** Wideband.

1. Introduction

Dielectric Resonators (DR) have become famous due to its merits such as negligible conductor loss, wide bandwidth, high radiation efficiency, low cost, lightweight and easy excitation. Since the mid-1960s to present, one of the research area explored is wideband DRA [1]-[3]. Modifying shape of DRA is one of the methods used to enhance bandwidth. In this method curves, notch [4], tunnel [6] may be applied to the solid DRA; this introduces discontinuities in DRA and lowers its Q-factor hence improve the impedance bandwidth. In [4], [5] a single notch is grooved at the bottom of DRA to yield impedance bandwidth of 28%. In this work, the proposed rectangular DRA has four notches of equal size and equally spaced grooved at the bottom of DRA across its length.

2. Theory

The DRA with a rectangular cross-section is characterized by a height h, a width w, a depth d, and a dielectric constant εr. Among the three basic shapes, the rectangular DRA provides the highest flexibility in terms of design with two degrees of freedom (depth/width and length/width). The resonance modes present in an isolated rectangular shaped dielectric guide is divided into TE mode and TM mode. $TE_{11\delta}$ is the principle mode whose resonant frequency can be obtained by solving the transcendental equation below:

$$k_x \tan\left(k_x \frac{d}{2}\right) = \sqrt{((\varepsilon r - 1)k_o - k_x^2)} \qquad (1)$$

Where:

$$f_o = \frac{2\pi}{\lambda_o} = \frac{2\pi f_0}{c},\ k_y = \frac{\pi}{w}\ k_z = \frac{\pi}{b}$$

$$k_x^2 + k_y^2 + k_z^2 = \varepsilon r k_o^2 \qquad (2)$$

$$f_o = \frac{c}{2\pi\sqrt{\varepsilon r}}\sqrt{(k_x^2 + k_y^2 + k_z^2)} \qquad (3)$$

Where c, fo, ko and are the speed of light, free space resonant frequency respectively and wavenumber.

3. Antenna configuration

Fig 1 shows the top view and side view of the proposed rectangular DRA of length *Wx*, width *Wy*, height *Hd* and relative permittivity *εr* placed on a square rectangular ground plane with side *Wg*. A cylindrical probe of radius *Rp* and height *Hp* extended by distance *X* from the center is inserted through the DRA. Four notches of volume (*P*) x (*Wy*) x (*H*) are equally spaced by distance *P* across the length *Wx* of DRA are grooved at the bottom. The improved parameters of the proposed antenna are displayed in the Table1.

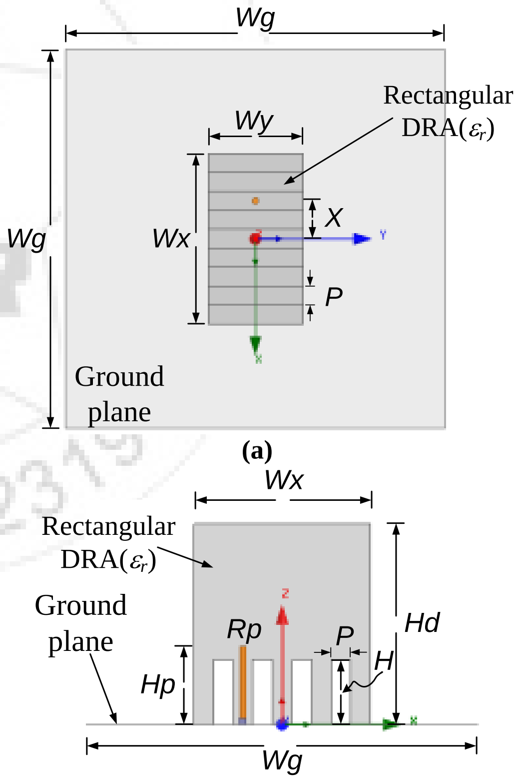


Figure 1: The configuration of the proposed antenna. (a) Top view, (b) Side view.

Table 1: The optimized parameters of the antenna

Parameter	Value	Parameter	Value
Wx	27mm	*Rp*	0.5mm
Wy	15mm	*Hp*	12mm
Wg	80mm	*H*	10mm
P	3mm	*Hd*	31mm
X	6mm	ε_r	15

4. Results and Discussion

The proposed rectangular DRA operating at 3GHz is designed and simulated in High-Frequency Structure Simulator (HFSS 2014). **Fig.2** shows the combined return loss $|S_{11}|$ and realized gain of the proposed DRA. The simulated impedance bandwidth ($|S_{11}| < -10$ dB) of 37.8% is exhibited extending from 2.25GHz to 3.3GHz, this is to say the absolute bandwidth exhibited is 1.05GHz. Two resonances are observed around 2.25GHz and 3GHz. The antenna has the average gain of 4.45dBi across impedance passband ($|S_{11}| < -10$ dB). Maximum gain (6.4dBi) is found at 3.08GHz and minimum gain (2.5dBi) is found at 2.98GHz.

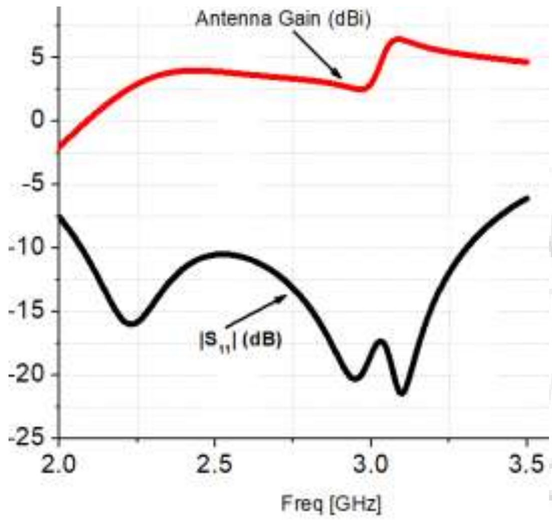
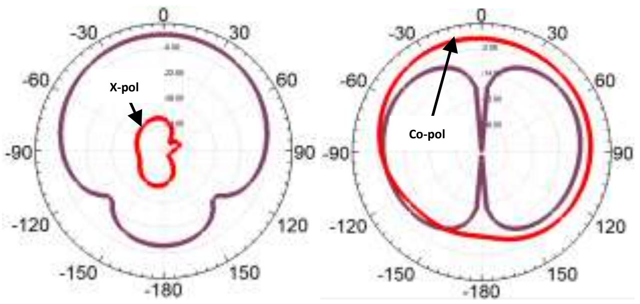


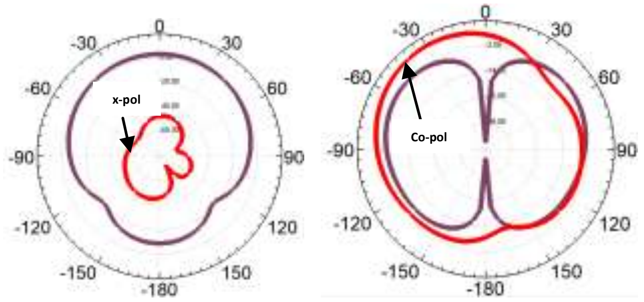
Figure 2: Combined graph of the simulated reflection coefficient and Realized Gain

The absolute bandwidth is arbitrarily divided into two portions. These are; from 2.25GHz to 2.75GHz and from 2.75GHz to 3.25GHz. **Fig 3** shows H-plane and E-plane radiation pattern of 2.25GHz, 2.75GHz, and 3.25GHz respectively. Generally the antenna exhibit broadside radiation pattern. The cross polarization of E-plane at (theta=0°) is small compared to co-polarization at (phi=0°). The direction of the main lobe at 2.25GHz, 2.75GHz, and 3.25GHz are -14°,-35°, and -22° respectively. **Fig.4** shows the electric field inside the DRA at 2.25GHz and 3GHz respectively. It can be observed that the modes exhibited are equivalent to $TE_{\delta 11}$ and $TM_{\delta 13}$ respectively.



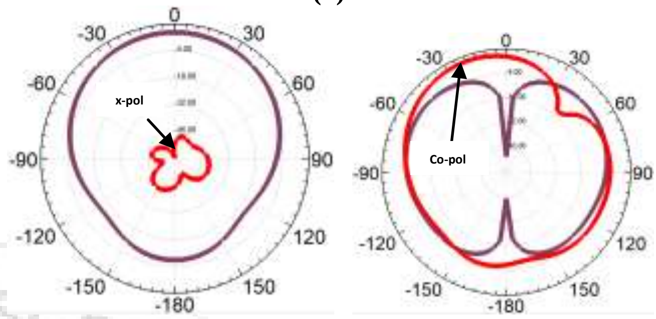
H-plane E-plane

(a)



H-plane E-plane

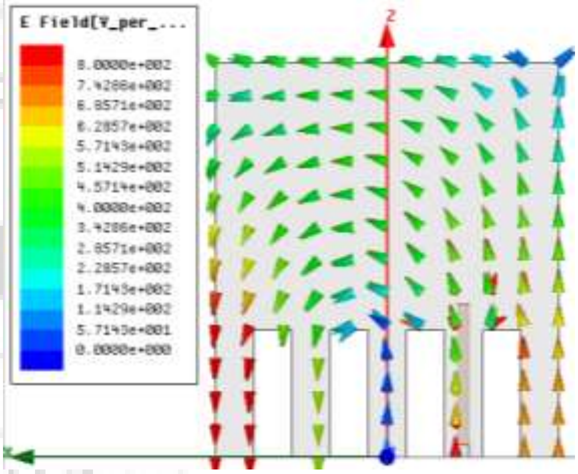
(b)



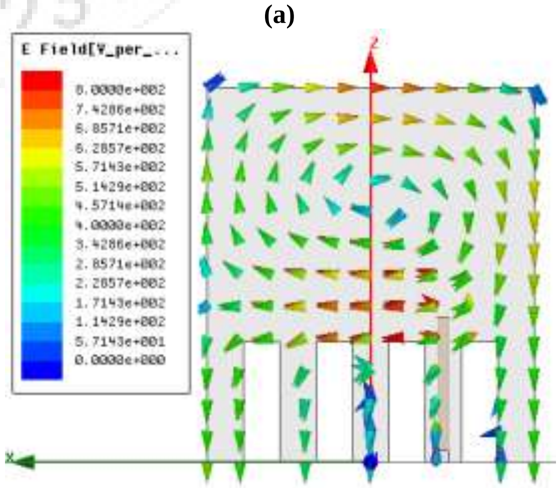
H-plane E-plane

(c)

Figure 3: Radiation pattern of the proposed DRA. (a) at 2.25GHz, (b) at 2.75GHz, (c) at 3.25GHz. The parameters are the same as in Figure 1



(a)



(b)

Figure 4: Simulation of E-field inside DRA across X-Z plane (a) at 2.25GHz ($TE_{\delta 11}$), (b) at 3GHz ($TE_{\delta 13}$). The parameters are the same as in Figure 1

5. Conclusion

The proposed wideband notched rectangular DRA was designed and simulated using HFSS 2014. The impedance bandwidth ($|S_{11}|$ < -10 dB) of 37.8% have been achieved with the average gain of 4.45dBi across the passband by merging principal mode $TE_{\delta 11}$ and the higher order mode $TE_{\delta 13}$. Broadside radiation patterns with minimum cross-polarization have been obtained for the E-plane across the passband. The proposed antenna can cover 2.3GHz, 2.5GHz WiMAX, 2.4GHz WLAN.

6. Acknowledgment

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References

[1] K. M. Luk, K. W. Leung, and K. W. Chow, "Bandwidth and Gain Enhancement of a Dielectric Resonator Antenna with the Use of a Stacking Element," Microwave and Optical Technology Letters, 1 4, 4, March 1 997, pp. 2 1 5-217.
[2] A. Sangiovanni, J. Y. Dauvignac, and C. Pichot, "Embedded Dielectric Resonator Antenna for Bandwidth Enhancement," lEE Electronics Letters, 33, 25, December 1 997, pp. 2090-209 1.
[3] A. A. Kishk, A. W. Glisson, and 1. P. Junker, "Study of Broadband Dielectric Resonator Antennas," 1 999 Antenna Applications Symposium, Allerton Park, Monticello, IL, September 1 999, pp. 45-68.
[4] A. Ittipiboon, A. Petosa, D. Roscoe, M. Cuhaci, "An Investigation of a Novel Broadband Dielectric Resonator Antenna", *1996 IEEE International Symposium on Antennas and Propagation Digest*, pp. 2038-2041.
[5] Ittipiboon, A., et al., “Broadband Nonhomogeneous Multisegmented Dielectric Resonator Antenna,” US Patent 5,952,972, Sept.14,1999.
[6] T. Chang, Y. Huang, W. Su, J. Kiang, "Wideband dielectric resonator antenna with a tunnel", *IEEE Antennas and Wireless Propagation letters*, vol. 7, pp. 275-278, 2008.

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