Wideband Omnidirectinal Perforated Minkowski Fractal Dielectric Resonator Antenna

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***Abstract*—A wideband perforated minkowski fractal dielectric resonator antenna is proposed. The antenna is centrally fed by a probe and operating in quasi $TM_{01\delta}$ mode which is similar to the $TM_{01\delta}$ mode of cylindrical dielectric resonator antenna. An impedance bandwidth (S_{11} < -10 dB) of 2.48 GHz (47%) is obtained and the peak gain varies from 3.6 dBi-4.05 dBi in the matching band with maximum at 5.5 GHz. The antenna radiates like electric monopole, resulting in omnidirectional radiation pattern. The radiation pattern is stable throughout the matching band and cross polarized levels are below -40 dB and -20 dB in xz- and xy-plane, respectively.**

I. Introduction

In the early 1980s, Long *et. al.* [1] proposed cylindrical dielectric resonator as a radiating element and since then they are widely used because of their attractive features such as small size, high radiation efficiency, no inherent conductor loss, relatively wide bandwidth as compared to microstrip antennas [2]. The basic shapes investigated were cylindrical, hemispherical and rectangular. Among these shapes, rectangular has more degree of freedom which provide more flexibility to design the antenna. With the rapid increase in wireless communication, the multi-band and wide-band antennas are in great demand to accommodate large number of wireless communication channels. In the last few decades, significant efforts have been made to broaden the operational bandwidth of the dielectric resonator antenna (DRA) [3]-[6]. Self-similar property of the fractals has also been employed in recent years to enhance the bandwidth of the DRAs [6]-[7]. All of these designs produces broadside radiation pattern. Recently, some omnidirectinal rectangular DRAs have been proposed [8]-[9]. In omnidirectinal rectangular DRA, the fundamental mode is quasi-$TM_{01\delta}$ which is analogous to $TM_{01\delta}$ mode of cylindrical DRA and it radiate like an electric monopole.

In this paper, perforated minkowski fractal DRA is investigated for wideband applications. The proposed antenna is centrally fed by probe resulting omnidirectional radiation pattern.

II. Antenna Design

Fig. 1 shows the configuration of the proposed antenna. The antenna is centrally fed by a coaxial probe of length L_p *(=6.4mm)*. Firstly, an euclidean rectangular DRA (RDRA) is designed at 3.4 GHz using Ansys HFSS. The DRA has the dielectric constant of $\epsilon_r = 10.2$ and dimensions of *A=33mm, B=21mm, h=15mm*. The field distribution of RDRA shown in Fig. 2 is similar to the field distribution on $TM_{01\delta}$ mode of cylindrical DRA. Thus, the mode excited can be regarded as quasi-$TM_{01\delta}$. The minkowski fractal dielectric resonator antenna (MFDRA) [7] is obtained by removing the middle one third of the each segment of RDRA by some fraction known as indention width (a, b). In this paper, only one iteration is performed to get minkowski fractal. Perforations are done in the four arms of MFDRA which results in the proposed antenna (Fig. 1), which we referred as perforated minkowski fractal dielectric resonator antenna (PMFDRA).

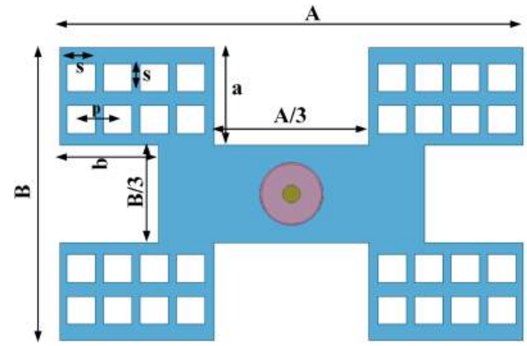

Fig. 1. Configuration of proposed antenna (a) Top view. *A=33mm, B=21mm, a=7mm, b=7mm, s=2mm, p=2.6mm*

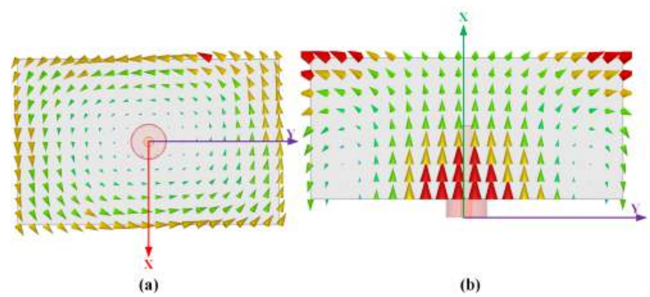

Fig. 2. Field distribution in rectangular DRA (a) H-Field (b) E-Field

III. Results and Discussion

Fig 3 shows the simulated response of the proposed antenna. The self-similarity of fractal structures results in a multi-band and wideband behavior and also helps to merge the higher order modes together [7]. The perforations in the structure helps in lowering effective dielectric constant, which lowers the radiation Q-factor ($Q_{rad} \propto (\epsilon_{eff})^p \left(\frac{volume}{surface}\right)^s, p > s \geq 1$). This tends to increase the antenna bandwidth. Also, due to

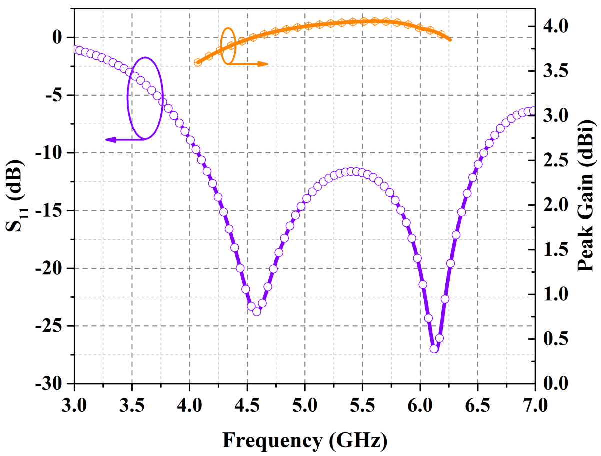

Fig. 3. Simulated reflection coefficient and peak gain of the proposed antenna

the decrease in effective dielectric constant the frequency of fundamental mode shifts in higher side from 3.4 GHz to 4.58 GHz. An impedance bandwidth ($S_{11} < -10$ dB) of 2.48 GHz (47%) is achieved by the proposed antenna . Table I summarizes the bandwidth comparison between the RDRA, MFDRA and PMFDRA. The field distribution of proposed

TABLE I. BANDWIDTH COMPARISON OF RDRA, MFDRA AND PMFDRA

Configuration	First Resonant Frequency (GHz)	Bandwidth (GHz)
RDRA	3.38	0.48 (14%)
MFDRA	4.07	0.74 (18%)
PMFDRA (Proposed)	**4.58**	**2.48 (47%)**

antenna at two different frequency is depicted in Fig 4. As can be observed from the figure, the field distribution at 4.58 GHz is similar to the distribution Fig 2, which confirms the excitation of fundamental quasi-$TM_{01\delta}$ mode.

The simulated normalized radiation patterns of the proposed

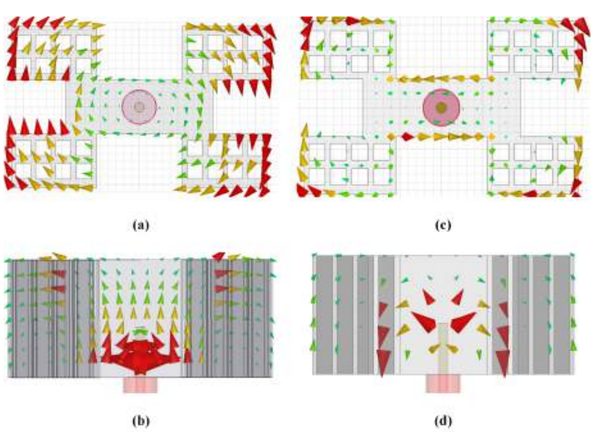

Fig. 4. Field distribution (a) Top view: H-Field (4.58 GHz) (b) Front view: E-Field (4.58 GHz) (c) Top View: H-Field (6.14 GHz) (d) Front view: E-Field (6.14 GHz)

antenna (PMFDRA) is shown in Fig 5. The radiation pattern of the proposed antenna is fairly stable throughout the matching band. The cross polarized levels are below -40 dB in xz-plane and same is below -20 dB in xy-plane. The peak gain varies from 3.6 dBi-4.05 dBi in the matching band with maximum at 5.5 GHz as depicted in Fig. 3.

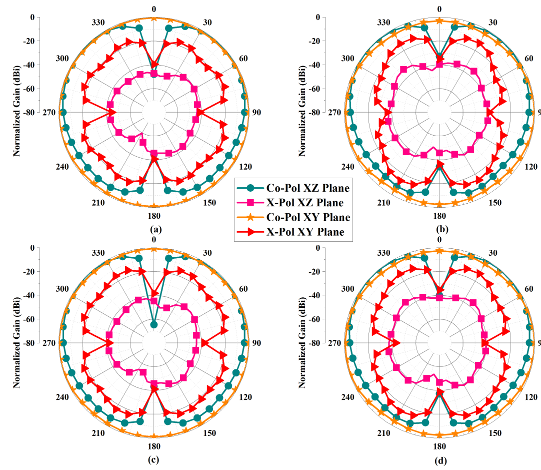

Fig. 5. Normalized radiation pattern (a) 4.58 GHz (b) 4.96 GHz (c) 5.84 GHz (d) 6.14 GHz

IV. Conclusion

An omnidirectional wideband dielectric resonator antenna has been proposed. An impedance bandwidth of 2.48 GHz (47%) has been obtained. The peak gain of proposed antenna varies from 3.6-4.05 dBi with maximum at 5.5 GHz. The radiation pattern is fairly stable throughout the matching band with low cross polar levels. The proposed antenna is good candidate for WLAN applications.

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