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Inverted E Fractal Antenna for Wideband Application

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Abstract: In this paper, an Inverted E Fractal antenna is designed. The patch has the dimension of 20 mm × 18 mm. Iterations are done using reverse fractal geometry. The antenna resonates at two frequencies which are 11.0GHz and 31.0 GHz with return loss of -26.1308 dB and -19.8463 dB respectively with considerable gain. The bandwidths are 14.0289 GHz and 14.2082 GHz respectively.

Keywords: Fractal Antenna, Multiband, Inverted E Fractal Antenna, UWB, Self-similarity, Space Filling Curves.

I. INTRODUCTION

The miniaturization of antenna design based on fractal geometry is of great interest in today's wireless communication systems. In the recent time, there is a considerable demands for dual band antennas for RF ends of cognitive radios or software defined radios. Multiband nature of antennas is required in each and every aspect of communication system. The antenna size must be small enough so that it can be fixed in communication devices. The researchers have developed many antennas with reduced size and multiband characteristics. Fractal antenna support these parameters. The name 'fractal' , from the Latin 'fractus' meaning broken, was given by Benoit Mandelbort [1] in his foundation essay in 1975 and classifying structures whose dimension were not a whole number. The fractal geometry has unique geometrical features occurrences in nature [2]. Fractals have the property to give the multiband frequencies from same structure [3]. This is mainly due to self –similarity property of fractals which means that some of their parts have the same shape as whole object but at different scale [4].

In addition, due to their space filling properties, it increases the electrical length of antenna. Therefore, the fractal geometry allows miniaturization of radiators with small over all dimensions [5].

Fractal Structures are generated by Iterated Functions System (IFS) [6]. In this technique each design is iterated or removed from the original structure which is similar to the original structure. The iteration is done by using the scaling factor [6] which is determined by

$$\mathcal{L} = \frac{n}{n+1} \tag{1}$$

In this presented design the fractal antenna gives multiband behaviour with considerable large bandwidth which in turn can be employed for various applications [7].

The paper is divided into four sections. Section II describes the antenna configuration whereas section III describes the results of proposed antenna. The conclusion and future work is discussed in section IV.

II. ANTENNA DESIGN

The dimension of antenna is a function of its operating wavelength i.e. λ/4. If the antenna size is less than λ/4, then radiation resistance, gain and bandwidth are severely affected and antenna performance becomes inefficient. The size of the designed antenna is 20 mm × 18 mm. The main antenna structure is of E shape with two inverting E on one plane. This part of antenna is zeroth iteration. Now as theory of fractal geometry says same self-similar design with scaling factor should be designed to get multiband characteristics [5]-[6]. In the proposed design self – similarity is taken into account with space filling curves [8] but with inverse fractal geometry. After first iteration the design is same and fulfils the criteria of fractal geometry and gives multiband characteristics. The antenna is simulated using HFSS simulator. Figure 1 shows the inverted E antenna design with 1st iteration.

The micro-strip antenna can be represented by width 'W' and height 'h' separated by two impedance transmission line of length 'L'. Now the parameters of antenna are calculated by the following procedures [7] –

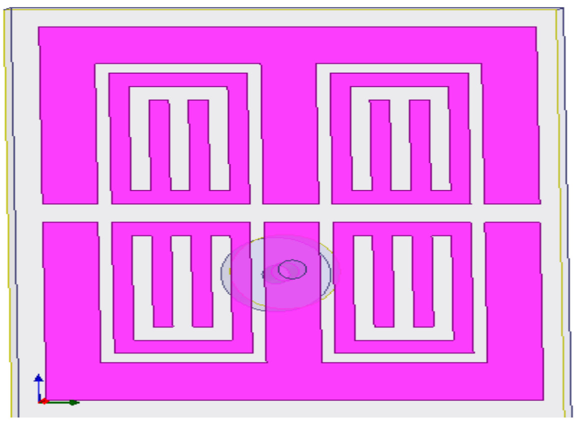

Figure1. Inverted E Shaped Fractal Antenna with first iteration

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(A) Calculation of width W of antenna, which is given by

$$W_p = c/(2 * \frac{f * \sqrt{\varepsilon_r + 1}}{\sqrt{2}})$$

B) Calculation of effective dielectric constant, μ_{eff} which is given by

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} / \sqrt{[1 + 12 * \frac{h}{W_p}]}$$

C) Calculation of the effective length, L_{eff} which is given by

$$L_{eff} = \frac{\lambda_o}{2f_r \sqrt{\varepsilon_{eff}}}$$

Calculation of length extension l, which is given by

$$L_p = \{\left[\frac{c}{2 * f * \sqrt{\varepsilon_{reff}}}\right] - 2\left[0.412 * h * \frac{(\varepsilon_{reff} + 0.3) * \left(\frac{W_p}{h} - 0.264\right)}{(\varepsilon_{reff} - 0.258) * \left(\frac{W_p}{h} - 0.8\right)}\right]\}$$

III. RESULTS & DISCUSSION

HFSS Electromagnetic simulator is used to simulate proposed inverted E fractal antenna. The return loss (S_{11}) graph and parameter is shown in figure 2.

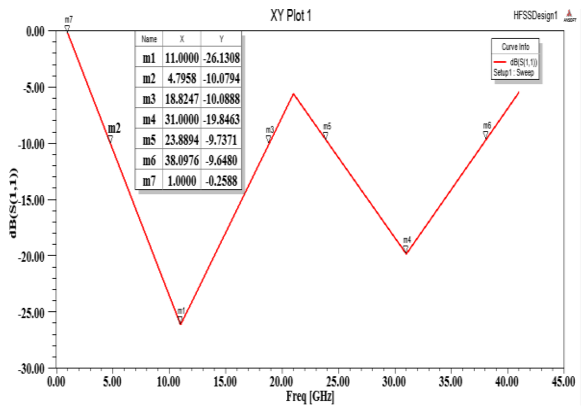

Figure 2. Return loss (S_{11}) of the Inverted E Fractal Antenna

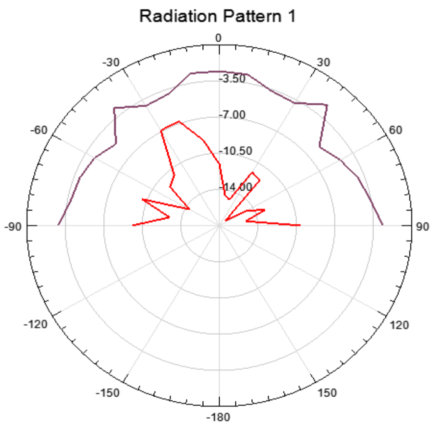

Figure3 3D radiation pattern of the inverted E fractal antenna

Figure 2 depicts the S_{11} parameters with two frequency bands. The resonating frequencies are 11.0GHz and 31.0 GHz with return loss of -26.1308 dB and -19.8463 dB respectively. The bandwidth are 14.0289 GHz and 14.2082 GHz respectively with fractional bandwidth 127% and 45.2% respectively.

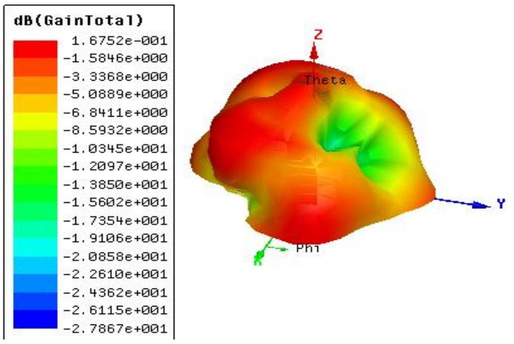

Figure 4 –3D polar plot of the inverted E fractal antenna

IV. CONCLUSION

The proposed Inverted E Fractal Antenna is a multiband antenna. The antenna offers large bandwidth however gain is not good which is yet to be explored. The antenna can be used for various applications such as microwave imaging, software defined radio /cognitive radio and for personal communication.

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