

Design of Circular Fractal Antenna with DGS for Wireless Application

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Abstract: Fractal scaled dimensions are basis for circular fractal antenna. The fractal antenna has the multiband operation due to the similar property in fractal geometry. It is based on finite element method for solving electromagnetic structures. A defected ground structure (DGS) for the circular fractal antenna is proposed in this paper. The proposed unit provides a large bandwidth and high gain in wireless applications by using fractal antenna. DGS improves the gain and antenna efficiency. This antenna is designed with High frequency structure simulator (HFSS) version 13. The proposed antenna resonate at 10 different frequencies 1.5GHZ, 1.9GHZ, 2.1GHZ, 2.2GHZ, 4.6GHZ, 5.1GHZ, 6.3GHZ, 8.1GHZ, 8.2GHZ, 9.7GHZ in (L,S,C,X) BANDS. Radius of the base antenna is 24mm and substrate thickness is 1.6mm. A circular fractal antenna with DGS can provide wide band for different applications.

Index terms: Circular fractal antenna, HFSS simulator, Sierpinski fractal, Wireless application, Defected Ground Structure.

I. INTRODUCTION

Now days a circular fractal antenna is used for many applications. The Structure of circular fractal antenna consists of mainly n iterations and each of this process is called as iteration [1]. The proposed circular fractal antenna can be used for many applications. For of GSM, Bluetooth, Wi-Fi, satellite, cellular phones, aircraft, missile application [2]. Another application WLAN and WIMAX [3]. The circular fractal antenna with DGS can be operated at different resonant frequency can be reduces size of the antenna and devices. The proposed antenna works efficiently at 1.5GHZ, 1.9GHZ, 2.1GHZ, 2.2GHZ, 4.6GHZ, 5.1GHZ, 6.3GHZ, 8.1GHZ, 8.2GHZ, and 9.7GHZ. All the frequencies are used for today's communication technologies. Fractals are generated from a simple object in an iterative fashion step by following some mathematical rule that follows the self-similarity and space filling property of fractal geometry. In this paper a new circular fractal antenna with DGS design is studied and proposed which operates in four bands (L, S, C and X band) and has self-similar and space filling property. In mobile satellite communication system, c-band technologies give bandwidth for application such as video, voice, and broadband connectivity. L-band terminal has almost 33% of the cost as compared with c-band system [10][11].

Defected ground structure concept has also been used to improve the bandwidth, gain and radiation. There are various shapes of DGS, such as rectangular cut in ground plane. The DGS which leads to maximum size reduction of circular fractal antenna.

II. ANTENNA DESIGN AND CONFIGURATION:

The proposed design of circular fractal antenna with DGS for wireless application is based on sierpinski fractal geometry. This antenna is designed on FR4 epoxy substrate with size of 85*60*1.6mm and $\epsilon_r=4.4$. The resonant frequency is 2.4GHZ using following equation which comes to be 24mm [4].

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi\epsilon_r F} \left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726 \right] \right\}^{1/2}}$$

$$F = \frac{8.791 * 10^9}{f_r \sqrt{\epsilon_r}}$$

Where,

a=radius of circular patch

f_r =Resonant frequency.

C=Velocity of light in free space

h=Substrate height.

ϵ_r =Dielectric constant of the substrate.

$$Z_0 = \frac{120\pi}{\sqrt{\epsilon_{eff}} \left[\frac{W}{H} + 1.393 + \frac{2}{3} \ln \left(\frac{W}{h} + 1.444 \right) \right]}$$

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}}$$

Where

ϵ_{eff} =Effective dielectric constant.

W=width of feed line.

Width of the feed line is 3 mm and height of substrate is 1.6mm resulting W/H ratio of 1.875(>1). To obtain characteristics impedance of 50 ohms following equation is used [10]. Base circular antenna is of the diameter 48mm. This length is calculating resonant frequency at 2.4GHZ. In the first iteration shown by, two circular patches are cut along axis of the feed line (D1=20mm). In the second iteration, Two more circles are subtracted from the base shape perpendicular to the feed axis (D2=12mm). In the third iteration four circles of diameter D3=4mm are placed in the circular patch. The ground plane is etched with rectangular shape; by keeping the rectangular size 26*60mm a wideband is obtained. The simulated geometry of proposed circular fractal antenna with DGS is shown in figure 1. All the dimensions are shown in table 1.

Table 1. Antenna Dimensions

S.No	Parameters	Description	Value (mm)
1	Lg	Length of substrate	86
2	Wg	Width of substrate	60
3	Lz	Length of feed line	27
4	Wz	Width of feed line	3
5	D0	Diameter of base patch	48.01
6	D1	Diameter of 1 st inner cut	20
7	D2	Diameter of 2 nd inner cut	12
8	D3	Diameter of 3 rd inner cut	4
9	Ldgsc	DGS cut length	26.94
10	Wdgsc	DGS cut width	60.005

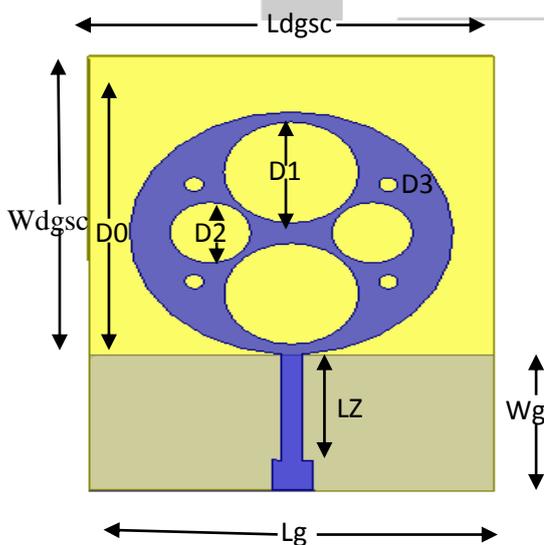


Figure 1. 3rd iteration of the circular fractal antenna with DGS

III. RESULT AND DISCUSSION

A. Return loss:

Return loss is the loss of power in the signal returned/reflected by a discontinuity in a transmission line (or) optical fiber. It is usually expressed as a ratio in decibels (dB). Figure 2 represents the return loss of -26.0915dB at resonance frequency 2.1GHz.

S.No	Band	Frequenc y	Return loss(dB)	Gain(d B)
1	L-band	1.5GHz	-16.0551	1.0136
2	L-band	1.9GHz	-16.9591	9.8946
3	S-band	2.1GHz	-26.0915	9.5618
4	S-band	2.2GHz	-20.7138	9.2951
5	S-band	4.6GHz	-10.8336	4.0210
6	C-band	5.1GHz	-14.1450	4.3004
7	C-band	6.3GHz	-10.7818	6.2512
8	X-band	8.1GHz	-15.6223	5.0970
9	X-band	8.2GHz	-26.2569	4.9924
10	X-band	9.7GHz	-11.8417	6.0221

Table.2 Return loss of the proposed antenna (3rd iteration) with DGS.

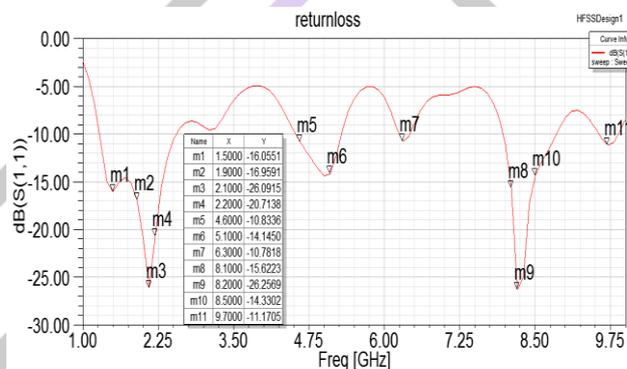


Figure 2. Simulated Return loss

B. VSWR:

Voltage standing wave ratio measures power reflected from antenna which describes about impedance matching of antenna. The vswr with value less than 2dB gives best result. Figure 3 represents the voltage standing wave ratio (vswr) less than 2 which produces a band width 1.3GHz from the frequency range 1.5GHz to 9.7GHz.

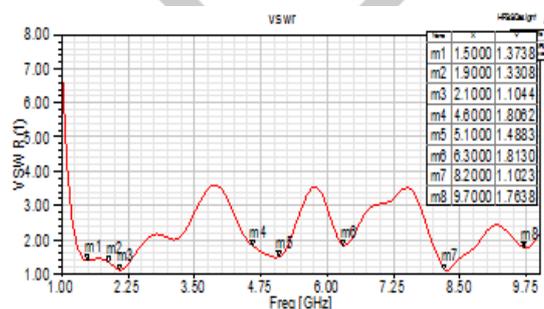


Figure 3: Simulated Voltage Standing Wave Ratio

C. Gain:

The gain patterns for the frequencies of 1.5GHz to 9.7GHz are shown in the fig 4. Gain obtained at the 1.0136dB, 9.8946dB, 9.5618dB, 9.2951dB, 4.0210dB, 4.3004dB, 6.2512dB, 5.0970dB, 4.9924dB and 6.0221dB at the frequency bands of 1.5GHz,1.9GHz,2.1GHz,2.2GHz,4.6GHz,5.1GHz,6.3GHz,8.1GHz,8.2GHz and 9.7GHz respectively.

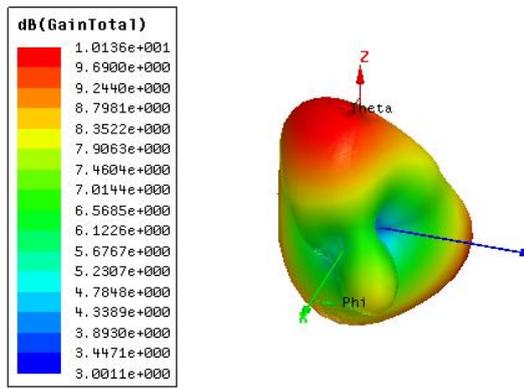


Fig. 4(a) Gain at 1.5GHz

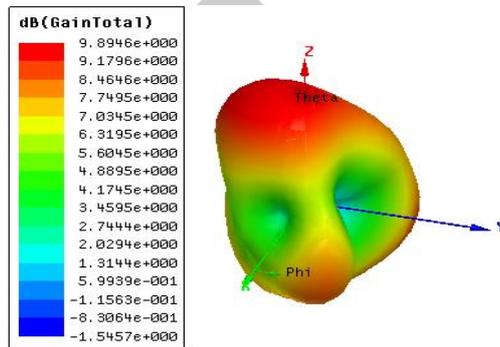


Fig. 4(b) Gain at 1.9 GHz

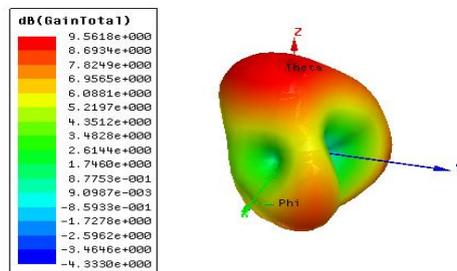


Fig. 4 (c) Gains at 2.1GHz

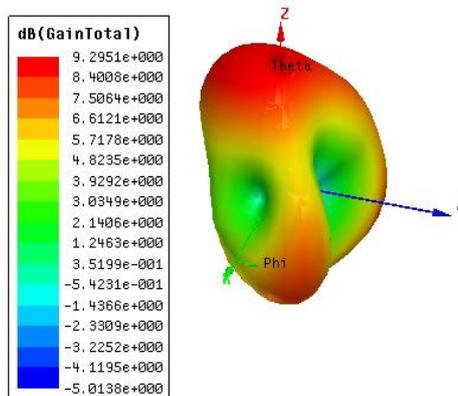


Fig. 4(d) Gain at 2.2GHz

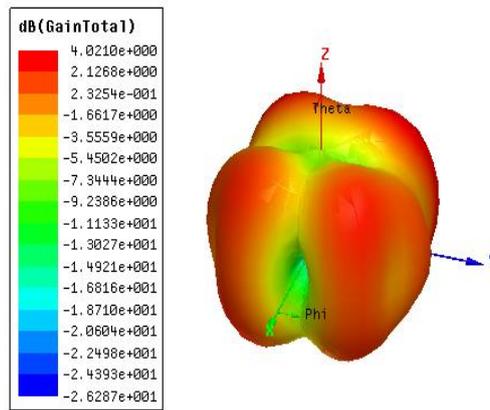


Fig.4 (e) Gain at 4.6GHz

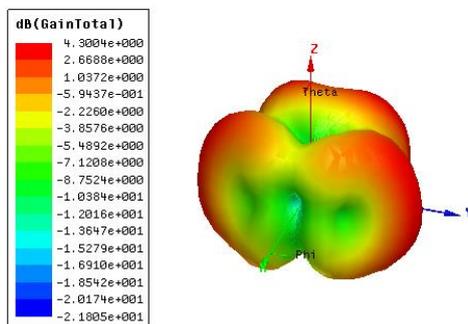


Fig .4(f) Gain at 5.1GHz

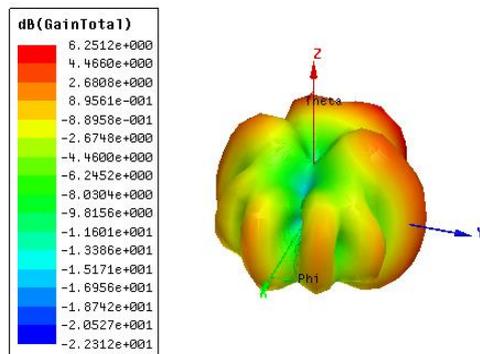


Fig .4(g) Gain at 6.3GHz

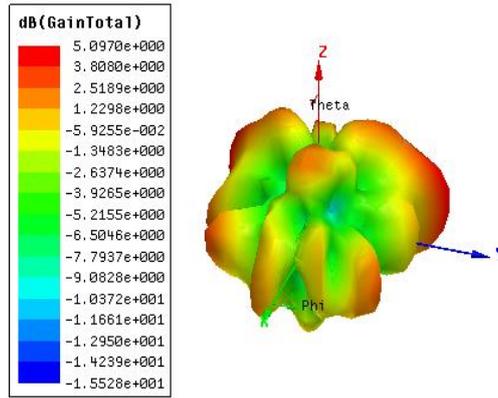


Fig.4 (h) Gain at 8.1GHz

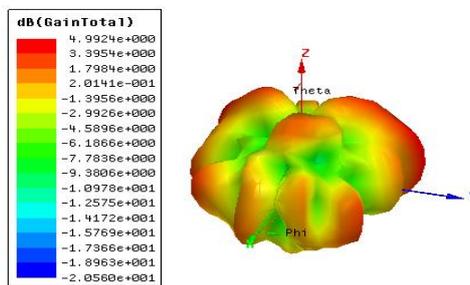


Fig.4(i) Gain at 8.2GHz

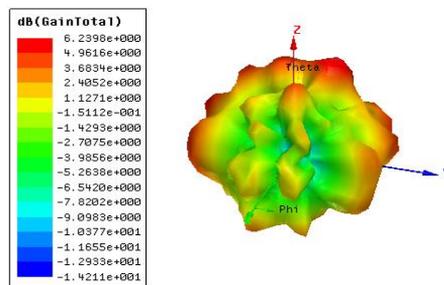


Fig.4(j) Gain at 9.7GHz

D.Radiation pattern:

The radiation pattern represents the variation of the power radiated by an antenna as a function of the direction away from the antenna. The radiation plots at 1.5 GHz are how shown in the fig.5

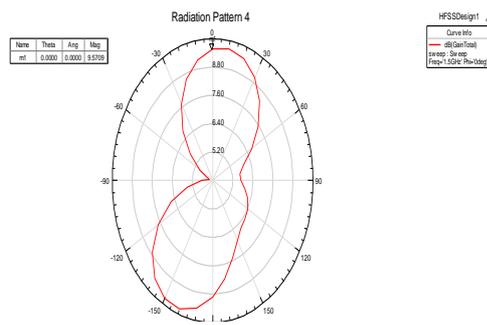


Fig.5 Radiation pattern

IV. CONCLUSION

A new circular fractal antenna design with DGS for wireless application has been proposed for L, S, C, X bands. By using circular fractal antenna and sierpinski and DGS, wide bandwidth and better efficiency are obtained. The proposed antenna can be used for fixed satellite, Bluetooth WI-FI, GSM, missile, WLAN and WI-MAX.

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