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Planar Compact Bidirectional Multi-band Fractal Antenna

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ABSTRACT

When the system requires operation at two or more frequencies, multi-frequency antenna may avoid the use of different antennas. Applying fractal to antennas allow for miniaturization of antenna with multi-band and broad-band operation, and with that rejecting other undesired frequency bands or noise frequencies. Fractal geometries have two common properties, space filling and self similarity. It has been shown that the self similarity property of fractal shapes can be applied to the design of multiband fractal antennas and the space filling property of fractals can be utilized to reduce antenna size [8-15].

Keywords: Planar antenna, compact antenna, Multi band antenna, bidirectional radiation pattern, Fractal.

1. Introduction

Wireless technology has undergone different phases of development ever since its inception and now has become premium area of research [3]. Presently, in strategic as well as public domain the wireless devices and systems need to cater to different frequencies, should be small in size, broadband and should be of low cost. The present study is based on one a comparatively new trend known as “Fractal Antenna”. It is now more than a decade in which geometrical characteristics of fractals are being applied in the design of passive components in the Radio Frequency and Microwave domain. B.B. Mandelbrot in the year 1975 first proposed that kind of antenna [4]. The word fractal means an object, which is indefinitely divided. Its Latin name is “fractus” that descends from the verb “frangere”, which means to break.

Now in wireless communication systems the demand for small size and miniaturized, broadband, multi frequency and multiband antenna was realized. In application such as Global Positioning System and Wi-MAX, operation at two or more sub-bends is necessary; a valid alternative to the broadening of total bandwidth is the use of multi-frequency antenna [6]. It has been shown that fractal antenna exhibit a multiple resonant behaviour in a single radiating structure [7].

When the system requires operation at two or more frequencies, multi-frequency antenna may avoid the use of different antennas. Applying fractal to antennas allow for miniaturization of antenna with multi-band and broad-band operation, and with that rejecting other undesired frequency bands or noise frequencies. Fractal geometries have two common properties, space filling and self similarity. It has been shown that the self similarity property of fractal shapes can be applied to the design of multiband fractal antennas and the space filling property of fractals can be utilized to reduce antenna size [8-15].

2. Antenna design

This is a Rectangular planar monopole antenna having a radiating patch of copper plate with 5 micrometer thickness, and the radiating patch is surrounded same copper plate in same plane which acts as ground plane of the antenna. The ground plate rectangle has been cut into fractal shape. An offset feeding from centre is given by SMA connector. A shorting strip is added between radiating element and ground. It has been experimented that shorting strip reduces the antenna size and makes more broad-banding possible.

The proposed multi frequency fractal patch antenna designed upto 5 iteration. The first iteration of fractal antenna has been constructed by inscribing the circular patch of diameter 40.48mm and subtracted it from square. The second iteration has been constructed by making the square of dimension 30 × 30mm and an inscribed circle with diameter of 29.4mm and subtracted it from the square. Likewise third iteration is constructed by making square of 22 × 22mm and inscribing the circle with diameter of 21.4mm and subtracted it from square. In the fourth iteration, a square of dimension 16 × 16mm is made and an inscribed circle of diameter 15.4mm is subtracted from it. In the fifth iteration, a square of dimension 12 × 12mm is made and an inscribed circle of diameter 11.4 mm is subtracted from square. All the five iteration of antenna along with patch dimension is shown in Fig 1. And levelling is done near feeding of the radiating copper plate to achieve good impedance matching.
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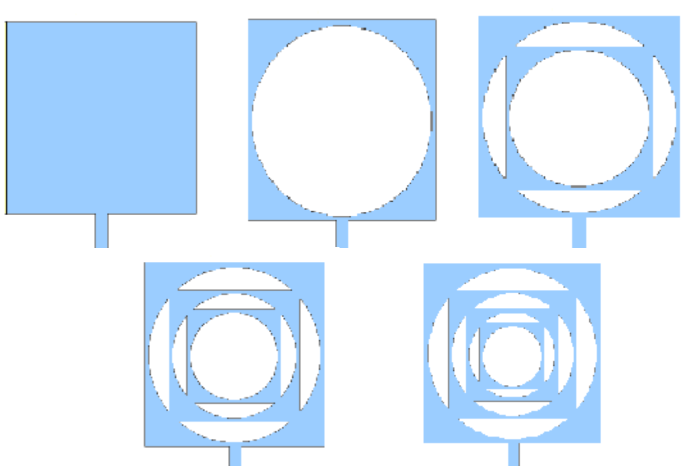

Figure 1: showing the gradual iterations of the previously proposed fractal antenna [1]

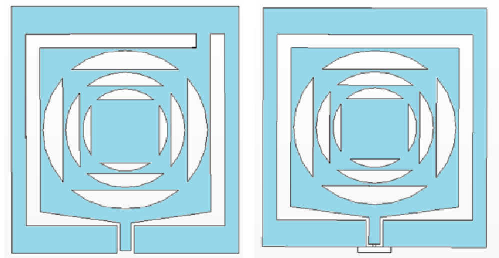

Figure 2: Final geometry of proposed shorted fractal antenna.

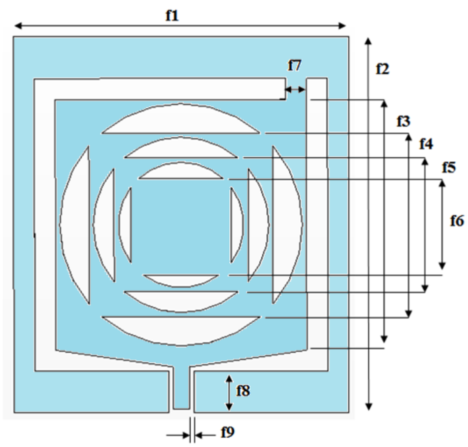

Figure 3: Geometry of the multiband fractal antenna: f1 = 80 mm, f2 = 90 mm, f3 = 60 mm, f4 = 44 mm, f5 = 32 mm, f6 = 22 mm, f7 = 4 mm, f8 = 10 mm, f9 = 1mm.

3. Simulated return loss

The simulated Return loss plot has been shown below. The simulation is done on the software named CST MICROWAVE STUDIO which is based on finite integration method (FIT).

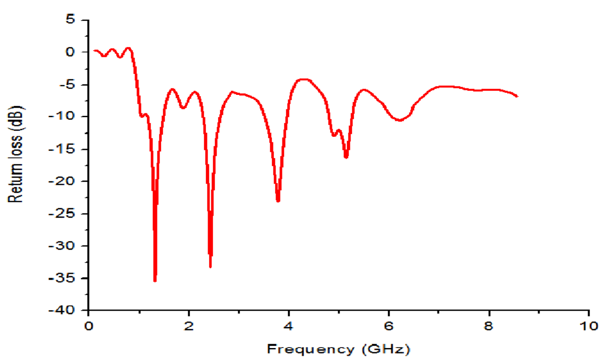

Figure 4: Simulated Return loss of the proposed multiband fractal antenna

4. Radiation pattern

This proposed antenna gives a stable bidirectional radiation pattern in both E and H plane in the operating frequency band due to its unique planar structure. The E plane radiation pattern at Φ=0° and Φ=90° for various frequencies at 2.4 GHz, 3.6 GHz, 5 GHz is shown.

The desired direction of peak beams in E plane are at ϴ = ±0˚, that is 0˚ and 180˚. The main beam is little bit tilted from its desired direction due to the shorting strip and offset feeding. In this elevation plane, radiation pattern in X-Z plane and Y-Z plane are not exactly same due to the non symmetrical structure of this antenna. The H plane pattern at ϴ = 0˚ are shown in Figure 5 & figure 6, which demonstrates this pattern is bidirectional. For some applications, bidirectional radiation patterns are more useful than omni directional radiation pattern in azimuth plane for monopole antennas. In H plane the desired direction of peak beams are at Ø= 0˚ and Ø = 180˚. At higher frequencies, ripples are introduced in radiation pattern of both planes.

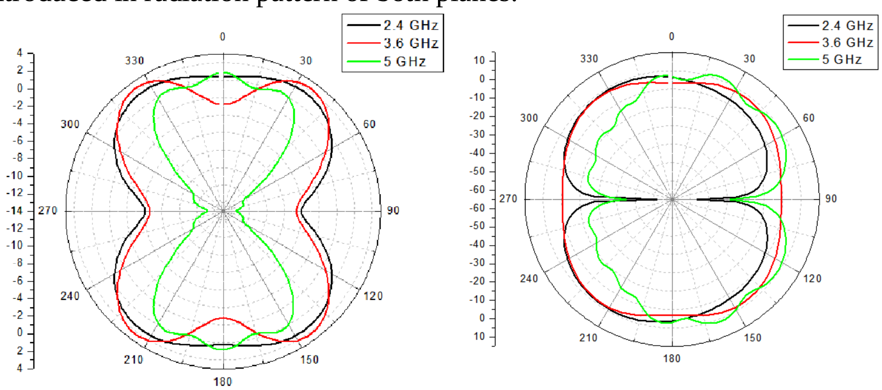

Figure 5: E plane radiation patterns (a) Ø=0˚, (b) Ø = 90˚

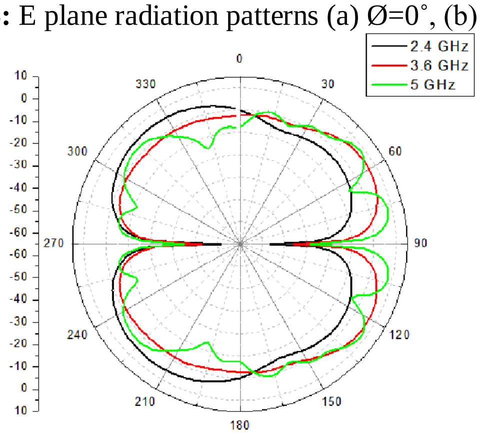

Figure 6: H -plane radiation patterns

5. Conclusions

The proposed monopole antenna has a wide operating frequency band of 1.8 GHz GSM band and WLAN bands 2.4 GHz, 3.6GHz. 5 GHz (VSWR < 2). It is observed that the radiation patterns of antenna in H-plane and E-plane is bi-directional radiation pattern over the entire operating bandwidth. The proposed fractal antenna design is compact, low profile, and offers good impedance bandwidth required for next generation Wideband systems as well as suitable for various military and commercial wideband applications.

The use of coplanar ground plane makes the design conformal and more suitable for the miniaturized applications. And our future scopes are: using the properties of fractal antennas fractal arrays can be created, including the frequency-independent multi-band characteristics, and utilize the ability to develop rapid beam-forming algorithms by exploiting the recursive nature of fractals.

REFERENCES

1. Dipakkumar J. Barasara, Jayeshkumar C. Prajapati, Ankitkumar M. Dethalia; Multi-frequency Fractal Antenna, International Journal of Scientific & Engineering Research, 3(7), 2012.
2. Andreas F. Molisch; Wireless Communications, Great Britain, John Wiley andSons2005.
3. B. B. Mandelbrot; The Fractal Geometry of Nature, San Francisco, CA: Freeman,1983.
4. Douglas H. Werner, Suman Ganguly, An Overview of Fractal Antenna Engineering Research, IEEE Antennas and Propagation Magazine, 45(1)(2003)38-57.
5. S. Natrajmani, S.K. Behera, R.K. Misra; Design of Multi Slotted and Multi Frequency Patch Antenna, in Applied Electromagnetic Conference, 2009, Kolkata.
6. S. Maci, G. Biffi Gentili; Dual Frequency Patch Antenna, in IEEE Antennas and Propagation Magazine, 39(6) 1997.
7. M. Kazerooni, A. Cheldavi; Design and Fabrication of Wide Band Printed Multi Ring Fractal Antenna For Commercial Application, in PIERS Proceedings, Beijing, China, March 23-27, 2009.
8. Yuan-hai Yu and Chang Peng Ji, Research of Fractal Technology in the Design of Multi Frequency Antenna, in CJMW 2011 Proceeding.
9. Raj Kumar, K.K. Sawant; Design of CPW-Fed Fourth Iterative UWB Fractal Antenna, International Journal of Microwave and Optical Technology, 5(6) 2010.
10. Rao Shahid Aziz, Majeed A. Alkanhal, Abdel Fattah A. Sheta; Dual Band Fractal Monopoles, in IEEE Transaction 2011.
11. R.L. Yadava, M.Ram, S. Das, Multiband Triangular Fractal Antenna for Mobile Communications, in International Journal of Engineering Science and Technology, 2(11) (2010) 6335-6348.
12. C.Puente, J.Romeu, R.Pous, X.Garcia, F. Benítez; Fractal Multiband Antenna Based on the Sierpinski Gasket, IEE Electronics Letters, 32(1) (1996)1-2.
13. C.Puente,J.Romeu, R.Bartolomé, R.Pous; Perturbation of the Sierpinski antenna to allocate the operating bands, IEE Electronics Letters, 32(24) (1996)2186-2188.
14. C. Puente, J.Romeu, R. Pous, A. Cardama; On the Behavior of the Sierpinski Multiband Fractal Antenna, IEEE Trans. on Antennas and Propagation, 46(4) 517-524, 1998.
15. C. T. P. Song, Peter S. Hall,H. Ghafouri-Shiraz; Multiband Multiple Ring Monopole Antennas, IEEE Transactions On Antennas And Propagation, 51(4) 2003.