Proximity Coupled Fractal Antenna for Wireless Applications

Yadwinder Kumar* and Priyanka Rani**
* **Electronics & Communication Engineering Section,
YCOE (Punjabi University Regional Campus) Talwandi Sabo, Bathinda, Punjab (India)
yaddi79@gmail.com, erpriyanka.mehta@gmail.com

Abstract: A multiband fractal antenna with proximity coupling feed is proposed. The proposed antenna geometry has fractal like shape and resonates at five different frequencies thus exhibiting multiband behavior. Accepted values of simulated results are obtained. Only those resonant frequencies are considered which have return loss values greater than -15 dB. The proposed antenna design has been examined up to 2nd iteration of the fractal geometry on RT duroid 5880 substrate material. Proposed antenna exhibits good radiation characteristics. Ansoft HFSS is used for all the simulations.

Keywords: Fractal, RT Duriod, Return Loss, VSWR, Bandwidth.

Introduction

The accelerating progresses of the modern telecommunication systems have created an ever-growing demand for multiband application. To cover these applications by one system, it requires a multiband compact sized antenna with adequate performance parameters [1]. Due to that in recent years several fractal geometries have been introduced for antenna with the varying degree of success in improving the antenna characteristics. There are many fractal geometries such as Sierpinski gasket, Sierpinski carpet, Koch curves and Hilbert curve etc used for multiband applications [2].

By using the slots with different shapes of fractal elements in micro strip patch antennas provides a multiband behavior with antenna miniaturization [3-5]. Some of these geometries are useful in size reduction and some provides the wide variety of multiband characteristic. To achieve both of these characteristics multiband behavior with antenna miniaturization is more difficult as it is the requirement of today's emerging trends [6-9]. Through the adding some degree of freedom to the reference fractal shape by applying the perturbations the non-harmonic resonant frequency bands can also be tuned [10-11].

Prefractal is a shape which seems similar to fractal geometry but not true fractal geometry**.** Prefractal geometries are built with a finite number of fractal iterations. These are obtained by the addition of some degrees of freedom to reference fractal shapes and allow one to tune to the desired frequency bands. For antenna synthesis these have been proven to be very useful in order to achieve antenna miniaturization and to enhance the bandwidth [10-11]. The design is based upon square prefractal geometry and uses the proximity coupled feed line. In the proximity coupling the feed line is used in between the two substrate layer like it is sandwiched between the two substrate layers [12]. The perturbations are applied in the structure to excite the antenna on multiple bands simultaneously. Generally the square fractal geometry can be used for both the size reduction and multiband applications.

Antenna configuration

Ansoft HFSS is used to design the proposed antenna structure. RT duroid 5880 substrate material. The size of each layer is 70 mm × 55 mm × 1.524 mm. The overall structure consists of two layers of substrate to increase the bandwidth and to reduce spurious feed radiation from the open end of the microstrip line. The upper layer known as superstrate is used to increase the effective permittivity of the antenna. A square metallic patch of 25 mm × 25 mm is designed on the top of superstrate layer. Then a square of 4 mm × 4 mm is removed from each corner of the metallic patch so that the current can easily resonate from patch. Fig. 1 shows the complete final design.

Results And Dsicussion

The formula used to calculate the effective permittivity of the antenna is

$$\mathcal{E}_{\mathrm{reff}} = \frac{\mathcal{E}_{\mathrm{r}}+1}{2} + \frac{\mathcal{E}_{\mathrm{r}}-1}{2}\left[1 \Big/ \sqrt{1 + 12h/w}\right] \tag{1}$$

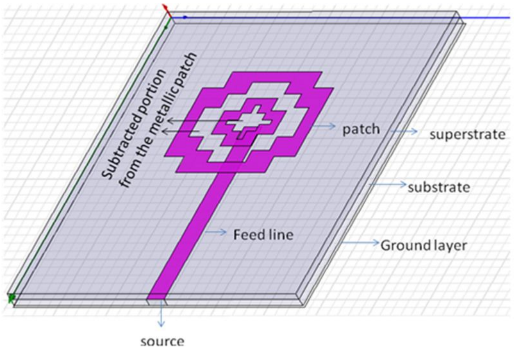

Fig. 1. Final design of proximity coupled multiband fractal antenna

In this equation the *h* and ε_r are thickness and relative permittivity of the upper layer of the substrate and *w* is the width of patch. Fig. 2 shows the 3D radiation pattern and total gain of 2^{nd} order prefractal antenna which shows the almost similar radiation pattern and total gain of 6 dB which is maximum as compared to previous two geometries.

Variation in Zero, 1^{st} and 2^{nd} oredr prefractal antennas

Fig. 3 shows the variation in return loss by using three different order prefractal antennas (0^{th} , 1^{st} & 2^{nd} order prefractal). As we can see that there are more number of resonant frequency bands & minimum return loss is obtained in 2^{nd} order prefractal antenna. The return losses are also minimum in 2^{nd} order prefractal antenna. So, 2^{nd} order prefractal antenna structure was chosen.

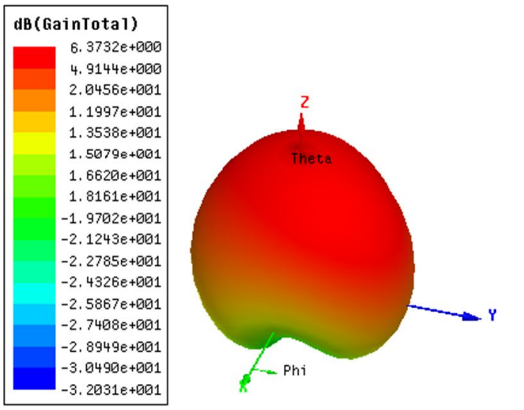

Fig. 2. Total Gain of 2^{nd} order prefractal antenna

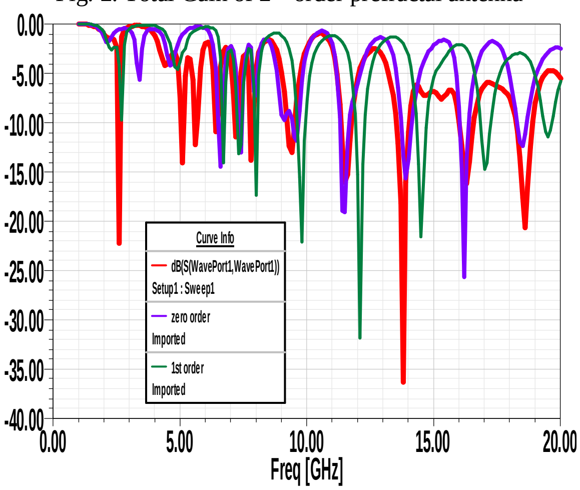

Fig. 3 Variation in return loss of zero, 1^{st} & 2nd order prefractal antenna

Table 1 Resonant frequencies and associated parameters

Frequency Band No.	Center Frequency F_R in GHz	Return Loss (dB)	B.W. (MHz)	VSWR
1	2.6	22.4	300	1.987
2	11.5	17	500	1.104
3	13.8	37	700	1.234
4	16.3	16	700	1.457
5	18.6	21	700	1.423

Table 1 shows the values of resonant frequencies and corresponding values of return loss, bandwidth and VSWR for each frequency band individually related to prefractal antenna for 2^{nd} iteration.

Conclusion

In this paper, a new proposed prefractal antenna having multiband behavior, based on square fractal geometry has been presented for wireless applications. The proposed prefractal antenna has been designed and simulated using HFSS finite element method based electromagnetic simulator. It resonates at five different frequencies 2.6 GHz, 11.5 GHz, 13.8 GHz, 16.3 GHz and 18.6 GHz, along with accepted values of return loss 22.4 dB, 17 dB, 37 dB, 16 dB and 21 dB. It also exhibits accepted values of VSWR. Every resonant frequency has narrow bandwidth ranging between 300 MHz and 700 MHz.

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