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Multiband Sierpinski Fractal with Triangular Geometry

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Abstract: ***Fractal has unique features such as geometry, filling space and resemblance. Fractal geometries have been utilized in antenna design to achieve the desired miniaturization, multi-band and broadband features. The paper offers a new geometry called the Sierpinski fractal, which has been modified for better performance compared to the traditional Sierpinski geometry. This paper presents the design and simulation of multiband Sierpinski fractal with triangular geometry. To validate the effect of fractal; antenna is designed using Rogers RT/duroid 5870™ as a substrate material. Also, the comparison using RT/duroid 5870™ and FR 4 as a substrate material has been provided to determine the best substrate material. The parameters in terms of return loss, gain and Voltage Standing Wave Ratio (VSWR) has been examined.***

Keywords: Sierpinski geometry. Triangular substrate, RT/duroid 5870™.

1. Introduction

Nowadays, microstrip patch antennas are frequently used in telecommunication products due to their low cost, low profile, light weight, and easiness of fabrication and integration [1]. Literately, when the microstrip patch antenna is excited, the electrical charges are accumulated at the edge of the patches. These electrical charges make curved fringing fields and therefore these fields at edge of the microstrip antenna generate electromagnetic radiation [2, 3]. Therefore, the parameters such as frequency, input impedance and gain of the antenna depend on the geometrical shape and the feeding type as well as the physical properties of the substrate [4].

The multiband behavior of the fractal-shaped antennas and of the Sierpinski fractal patch antenna has been described in [5]. The multiband properties of the Sierpinski are a consequence of its self similarity. Self similarity is a property common to many fractals, but in order to become a useful radiator it is necessary that the fractal antenna meet the specifications at the desired frequencies [6]. The Sierpinski gasket dipole reported in [7], is just one special case of a more general class of fractal objects called Pascal–Sierpinski gaskets. Furthermore, the geometry of the Sierpinski dipole can be altered by changing the flare angle. It is even possible to modify it in order to obtain a desired log-period band spacing [8]. In this paper, the multiband Sierpinski antenna has been designed in HFSS specially using substrate material RT/duroid 5870™ and the effect on return loss as well as on VSWR, gain has been analyzed.

2. Related Work

Kumar et al. [10] presented a triangular shape inverted fractal patch antenna. The proposed antenna resonates at multiple frequencies and provides good gain and directivity. In this antenna authors used two shorting pins in order to decrease return loss. When second iteration has been applied on the antenna the gain improved and becomes 8.68 dBi, 7.30 dBi and 6.33 dBi at three different resonant frequencies such as 2.3367 GHz, 5.39 GHz and 7.58. GHz.

Reddy et al. [11] proposed Koch curve based fractal patch antenna. The designed antenna used in WiMAx and WLAnapplicatios. That antenna had been used for circular polarization characteristics. Four different structures without slot have been analysed by different iterations of fractal geometry. The antenna resonates at three frequencies of 2.45 GHz, 3.4 GHz and 5.8 GHz having bandwidth of 3.2%, 1.6% and 3% respectively.

Prajapati et al. [12] presented a Koch curve fractal patch antenna along with defected ground structure (DGS).Plus shape slot has been designed on patch so that circular polarization has been achieved. It has been concluded that the fractal antenna has a number of advantages as compared to simple patch antenna. The advantages includes such as reduced size, increased bandwidth and decreased return loss.

Verma et al. [13] designed a novel Minkowski based fractal microstrip patch antenna. The proposed antenna used FR4 material as a substrate. The height of patch and ground is set at 5mm. Different iterations have been designed on the patch and hence increased the resonant frequency bands. The parameters such as return loss, radiation pattern, gain are measured and it is find that the proposed antenna used in wireless applications.

Waladit al. [14] proposed a printed star triangular shaped fractal patch antenna. The shape of ground is semi elliptical that helps in the reduction of the antenna size. The antenna has been fed by using microstrip line having dimensions of width × length is of 4.8mm×1.9mm. To enhance the wideband characteristics a rectangular notch of size 2.4mm2×1.6mm2 has been inserted at the feeding point in the ground plane. The proposed antenna covers frequency band ranges from 1GHz -30 GHz. The VSWR is less than 2 and find applications in UWB and SWB communication applications.

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3. Proposed Work

Following steps are followed to complete the design of proposed Multiband fractal patch antenna which is used for GPS applications.

Step 1: To determine the height, width and thickness of the proposed fractal antenna by selecting the desired operating frequency of the antenna.

Step 2: Rogers RT/duroid 5870™ material is used for the substrate of the antenna. Then patch is inserted over it in the triangular form and applied various fractal shapes on the patch.

Step 3: Then microstrip feed line is attached to the patch in order to excite the antenna.

Step4: Boundary condition such as E-filed in applied on the patch surface.

Step5: Air box is inserted on the designed antenna. This air box is used to observe the radiations emitted by the antenna and acts like load.

Step 6; After that the performance parameters like return loss, gain, VSWR and radiation pattern are measured.

Step 6: Now, the material of the substrate is changed in the proposed work we are using Roger material and also measure the QoS parameters.

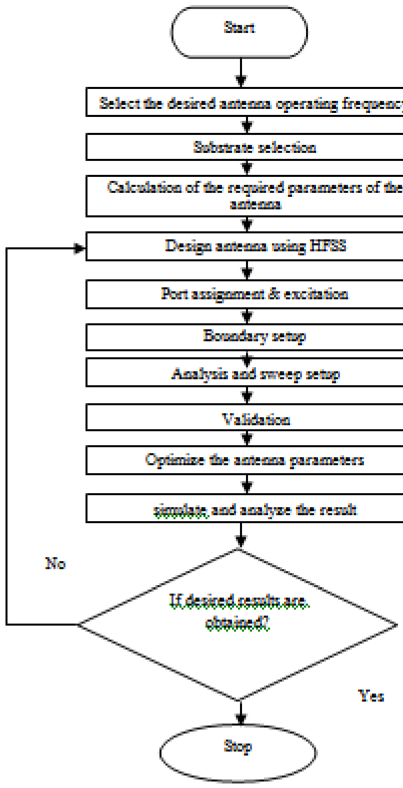

Figure 1: Flow of Proposed Work

3.1 Design and Implementation

Sierpinski fractal geometry is used to design microstrip patch antenna. Mainly six numbers of iterations are used to design a self similar structure using Rogers RT/duroid 5870™. The designed structure is shown in figure 1.

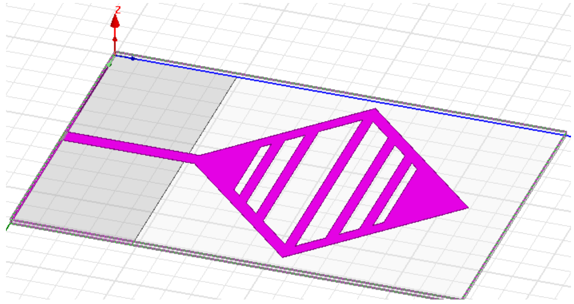

Figure 2: Designed Model

The model has been designed using HFSS simulator with ground of (62mm *24mm), substrate of (0.8mm). Sierpinski fractal geometry approach has been applied on triangular patch and the obtained structure is illustrated in figure 2.

4. Results and Discussions

The examined results such as return loss, VSWR, and gain are explained in this section. The definition of the measured parameters is provided below.

4.1 Return Loss

It is defined as the log ratio measured in dB, which compares the antenna's reflected power with the power fed from the transmission line to the antenna.

$$return\ loss = -10\log_{10}\frac{Power_t}{Power_i}$$

4.2 Voltage Standing Wave Ratio

This parameter describes how well the antenna is leaked to the transmit line. It is ratio of maximum voltage to minimum voltage in transmission line.

4.3 Gain

Gain is defined as the capability of a patch antenna to represents the radiated power in a particular direction.

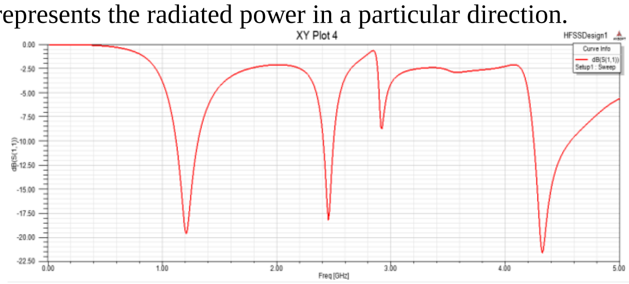

Figure 3: Return Loss

The return for solution frequency at f= 1.16 GHz is shown in figure 3. From the figure it has been observed that the designed antenna resonates at three different frequencies as depicted in table 1.

Table 1: Return Loss (dB)

Frequency (GHz)	Return loss(dB)
1.2	-19.52
2.4	-18.13
4.3	-21.48

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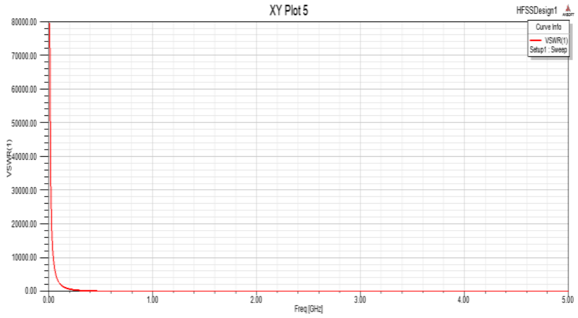

Figure 4: VSWR

The VSWR of the proposed antenna is shown in figure 4. It is the graphical representation of voltages with respect to the frequency. From the figure it has been observed that the VSWR is approximately reaches to 0 which indicates that the antenna radiates perfectly with 0 radiation loss and perfect impedance matching is obtained.

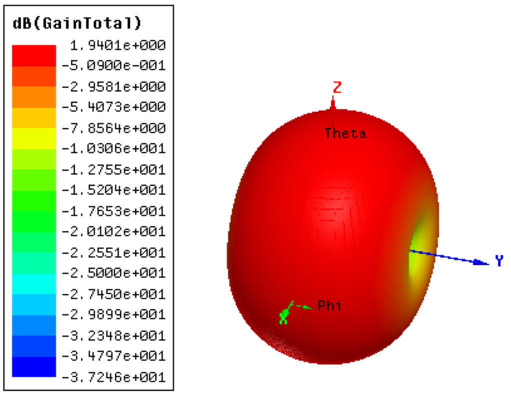

Figure 5: Gain

The above figure represents the gain obtained at 1.16GHz which is set as a solution frequency. The gain obtained for the proposed antenna is 1.94 dB. The positive value of gain represents that the antenna radiates with high power in a particular direction.

The comparison of the same design using FR4 as a substrate is shown in table below.

Table 2: Comparison of Return Loss and gain

RT/duroid 5870™.		FR4		RT/duroid 5870™.	FR4
Frequency (GHz)	Return loss(dB)	Frequency (GHz)	Return loss(dB)	Gain (dB)	Gain (dB)
1.2	-19.52	1.15	-15.21	1.94	1.83
2.4	-18.13	2.28	-26.61		
4.3	-21.48	2.60	-14.02		
		3.76	-10.90		

From the above table it has been examined that using RT/duroid 5870™ as a substrate material gain increased from 1.83 dB to 1.94 dB but the number of bands reduces.

5. Conclusion

The concept and simulation of a multiband microstrip patch antenna operating at 1.16 frequencies has been successfully developed using advanced design systems (HFSS). Observing the performance parameters such as VSWR, it is clear that this antenna operates in the designed GPS frequency range. This study detailed the design of our GPS multiband Sierpinski fractal antenna in the Advanced Design System and Ansoft High Speed Simulator.

References

[1] Hwang K. C. "A Modified Sierpinski Fractal Antenna for Multiband Application", *IEEE Letters on Antennas and Wireless Propagation*, Vol. 6, pp 357-360, 2007.

[2] Islam, Z. U., Rahman, M., Muhammad, N., Ahmed, Z., Lodhi, F. K., & Haneef, M., "Dual band second order modified Sierpinski monopole reduced size fractal antenna," In *Emerging Technologies (ICET), 2016 International Conference on* (pp. 1-5). IEEE.

[3] Mak, C. L., Luk, K. M., Lee, K. F., & Chow, Y. L. , "Experimental study of a microstrip patch antenna with an L-shaped probe. *IEEE Transactions on Antennas and Propagation*, *48*(5), 777-783, 2000.

[4] Tiwari, A., Pandey, B., Abitha, V. K., Mishra, R., Rane, A. V., & Suryawanshi, J., "Simulation of ultra-wideband co-planar boat microstrip patch antenna with IE3D software for wireless communication. *Science*, *1*(2), 10-13, 2016.

[5] Thomas, H. ," Microstrip Antenna Design with Parallel Rectangular Open Slots Structure for Multiband Operation, ,2016.

[6] Kumar, G. A., & Sarath, I. B. A., "Design and Simulation of EU Slot Microstrip Patch Antenna for Broadband Applications. *International Journal of Engineering Science*, *3593*, 2016.

[7] Garg, T., "Hexagonal Shaped Slotted Microstrip Patch Antenna. *International Journal of Engineering Science*, *217,"* 2016.

[8] Reddy, M. H., Joany, R. M., Reddy, M. J., Sugadev, M., & Logashanmugam, E., "Bandwidth enhancement of microstrip patch antenna using parasitic patch. In *Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), 2017 IEEE International Conference on* (pp. 295-298). IEEE.

[9] Tang, H., & Chen, J. X., "Microfluidically Frequency-Reconfigurable Microstrip Patch Antenna and Array. *IEEE Access*, 2017

[10] Sarma Kumar S., Gangwar D, "Miniaturized Inverted Multiband Stacked Triangular Fractal Patch Antenna for Wireless Communication" *IEEE Conference 2014 International Conference on Signal Processing and Integrated Networks (SPIN)* pp 667-670, 2014.

[11] Reddy V. V., S. N, "Triband Circularly Polarized Koch Fractal Boundary Microstrip Antenna "IEEE *Antennas And Wireless Propagation Letters, vol. 13*, 2014 pp. 1057-60

[12] P. R. Prajapati, "Design of Compact Circular Disc Circularly Polarized Antenna with Koch Curve Fractal Defected Ground Structure" IEEE *Antennas and Wireless Propagation* 3*Letters, vol. 13*, 2014.

[13] Verma Sudhanshu, Kumar Preetam, "Printed Multiband Minkowski Fractal Curved Antenna",*IEEE Conference*

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2014 International Conference on Signal Processing and Integrated Networks (SPIN) pp 690-94, 2014.

[14] Waladi V., Mohammadi N., Zehforoosh Y., Habashi A. and Nourinia J., "A Novel Modified Star Triangular Fractal (MSTF) Monopole Antenna for Super Wideband Applications", *IEEE Letters on Antennas and Wireless Propagation*, Vol. 12, pp 651-654, 2013..

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