Design and Implementation of Frequency Reconfigurable Antenna for ISM Band.

SHUDHANSU KUMAR, E&C DEPARTMENT SVIT VASAD
R.J.MAKWANA, E&C DEPARTMENT SVIT VASAD

ABSTRACT

Advancement in communication technology over past decade there is increasing demand for miniaturization cost effective multiband antenna. Fractal antenna design can support meeting this requirement .These antenna provide several advantage but at same time miniaturization and performance of the antenna further enhanced by the reconfigurable concept .A hybrid reconfigurable antenna at ISM frequency that combines the advantages of both the categories will be implemented. A reconfigurable antenna will be designed, simulated and optimized using HFSS software tool .This purpose antenna can be used in microwave oven, IEEE802.11 protocol, hypothermic, Radio frequency process heating and many others.

INTRODUCTION

The rapid expansion of wireless technology during the last years has led to increase in demand for small size, low-cost and multiband antennas for use in commercial communications systems. Fractal antenna [1] is one such category that provides miniaturization and have multi-band characteristic. These are composed of multiple iterations of a single elementary shape and are used to describe a family of complex shapes that possess an inherent self-similarity and self-affinity in their geometrical structure. Various researchers [2-4] have proposed fractal antennas of different shapes such as Sierpinski fractal antenna, tree-shaped fractal antenna [5], and some other types including snowflake fractal antenna [7] and Koch fractal antenna [8]. Though these antennas reduce the size and cost, but in case of communication system many applications are used that works at different frequency band hence a single fractal antenna cannot be used to serve the purpose of the whole communication system. To resolve this issue researchers have proposed reconfigurable antennas [9-10]. These antennas resonate at different frequencies at different time by using switches therefore reduces the cost and overall size of the system. In comparison to fractal antennas the reconfigurable antennas have the following advantages as follows:

a. Compact size
b. Effective use of electromagnetic spectrum
c. Similar radiation pattern and gain at all desired frequency bands

We are of the opinion that reconfiguration concept when applied to fractal can be a great asset for future wireless communication industries since it provides enhanced miniaturization in size of the overall communication system as well as provides frequency selectivity. Therefore this paper presents a frequency reconfigurable antenna that tries to incorporate the merits of the antennas.

Design of Antenna

Reference Antenna is a rectangular patch antenna designed on FR4 epoxy substrate having dielectric constant e_r= 4.4, loss tangent δ=.0025 and thickness = 1.6 mm as shown in Figure. This antenna is fed using micro strip line .Antenna design parameter for f=5.8GHz resonant frequency is calculated using transmission line model equations.For an efficient radiator, practical width W that leads to good radiation efficiencies is calculated by

$$w = c/2fr\sqrt{er + 1/2}$$

. The effective dielectric constant is obtained by referring to equation

$$\in reff = \frac{\in r + 1}{2} + \frac{\in r - 1}{2}\frac{1}{\sqrt{\left[1 + 12\frac{h}{w}\right]}}$$

The effective length is calculated using equation

$$Leff = \frac{c}{2fr\sqrt{\in reff}}$$

The value of ΔL can be obtained by using equation

$$\Delta L = 0.412h\left\{\frac{(\in reff + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\in reff - 0.258)\left(\frac{W}{h} + 0.8\right)}\right\}$$

The actual length of radiating patch is obtained by: Leff= L + 2ΔL

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. It has been shown by that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the ground plane dimensions would be given as:

Lg = 6h+W

Wg = 6h+W

The proposed reconfigurable fractal geometry is shown in Figure 1 and its design parameter is given in Table 1. For the purpose of reconfiguration, four RF switches D1-D4 are used. Antenna is fed with a strip line. Figure 2 shows the proposed antenna.

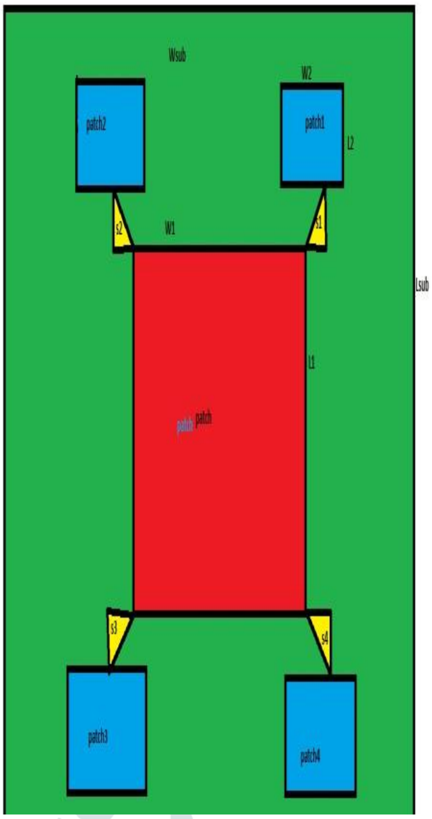
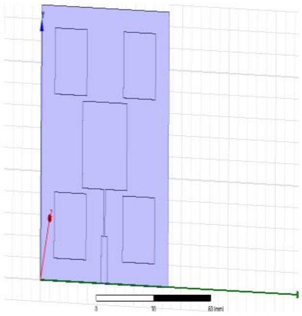
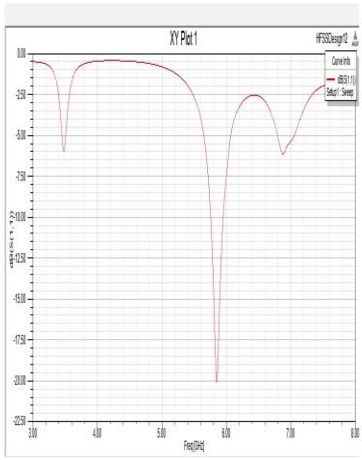


Figure 1 micro strip reconfigurable antenna

Table 1. Antenna dimension of proposed reconfigurable antenna

s.no	Antenna parameter	Dimension(mm)
1	Wsub	65
2	Lsub	60
3	W1	23.7
4	L1	20.02
5	W2	11.85
6	L2	9.87
7	$\in r$	4.4
8	H	1.6





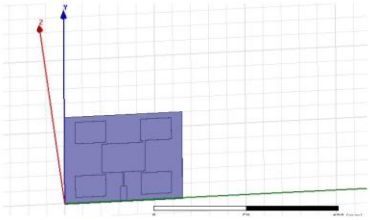
Simulated results presented here are obtained using HFSS software. This antenna is optimized for seven modes using different switch.

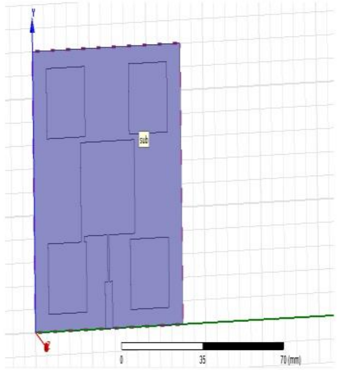
s.no	switches				Frequency (GHz)		Gain
	S1	S2	S3	S4	F1	F2	
1	0	0	0	0	5.80		1.76
2	0	0	0	1	5.81	6.45	1.79
3	0	0	1	0	5.86	6.44	1.82
4	0	1	0	0	5.83	6.40	1.72
5	1	1	0	0	5.83	9.45	1.29
6	0	1	1	0	5.81	6.51	1.69
7	1	0	0	1	5.83	7.1	1.34

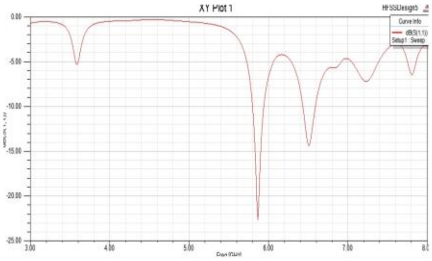
Results of different cases

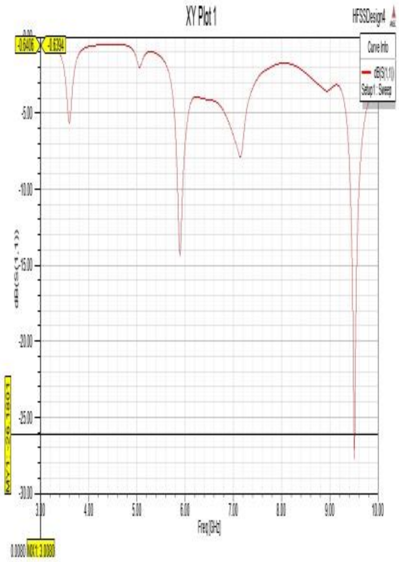
1) 0,0,0,0

2) 0,0,0,1




sub
0
35
70 (mm)

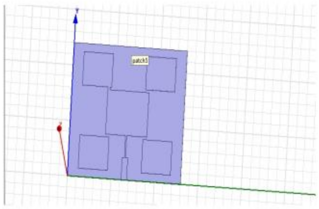

XY Plot 1

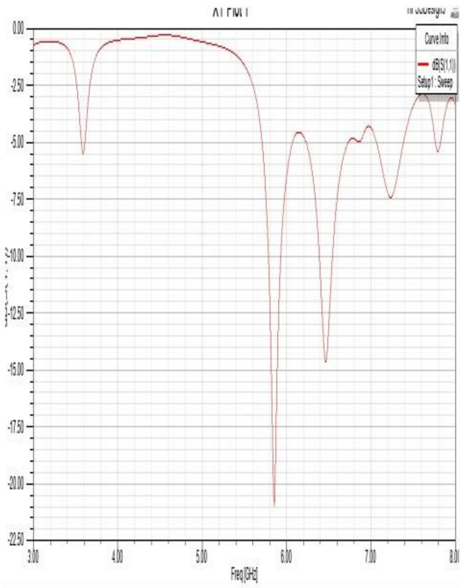

XY Plot 1
HFSSDesign4
Curve Info
dB(S(1,1))
Setup1 : Sweep
Freq [GHz]

.

3)0,0,1,0

4)0,1,0,0





Conclusion

The proposed reconfigurable antenna is compact, simple, multiband and reconfigurable. The presented antenna is multiband in each reconfigurable mode due to self-similarity of fractal structure. The antenna presents only one resonant frequencies if non-reconfigurable fractal configuration is used in which central patch is permanently connected to all small patches, but by using reconfiguration concept this antenna can resonates at approximately six different resonant frequencies in all the modes. Also by using reconfiguration concept power interference issues can be avoided by switching between different modes. The proposed multi-band reconfigurable antenna can be used for satellite communication, medical imaging and microwave imaging application, Vehicular radar applications and wireless industry application.

References

1. D. H. Werner and S. Ganguly, "An Overview of Fractal Antenna Engineering Research", IEEE Antenna and wave Propagation Magazine, vol. 45, no. 1, (2003) February.
2. K. C. Hwang, "A Modified Sierpinski Fractal Antenna for Multiband Application", Antennas and Wireless Propagation Letters, IEEE, vol. 6, (2007), pp. 357-360.
3. N. Kingsley, D. E. Anagnostou, M. Tentzeris and J. Papapolymerou, "RF MEMS Sequentially Reconfigurable Sierpinski Antenna on a Flexible Organic Substrate With Novel DC-Biasing Technique", Micro electro mechanical Systems, vol. 16, (2007) October, pp. 1185-1192.
4. H. F. A. Tarboush, R. Nilavalan, K. M. Nasr, H. S. Al-Raweshidy and D. Budimir, "A reconfigurable Hshape antenna for wireless applications", Proceedings of the Fourth European Conference on Antennas and Propagation, (2010) April, pp. 1-4, 12-16
5. Yogeshwari ,Panneer Selvam, Malathi Kanagasabai M. Gulam Nabi Alsath, Sangeetha Velan, Saffrine Kingsly, Sangeetha Subbaraj, Y. V. Ramana Rao, " A Low Profile Frequency and Pattern Reconfigurable Antenna''., IEEE Antennas and Wireless Propagation Letters LAWP VOL 1O PP.27599602017.
6. P.-Y. Qin, Y. Guo, Y. Cai, E. Dutkiewicz, and C.-H. Liang, " A reconfigurable antenna with frequency and polarization agility," IEEE Antennas Wireless Propag. Lett., vol. 10, pp. 1373–1376, 2011
7. Fatemeh Zadehparizi, and Shahrokh Jam "Increasing Reliability of Frequency Reconfigurable Antennas", /LAWP.2018.2823688, IEEE Antennas and Wireless Propagation Letters.

8. Preet Kaur, Asok De and S. K. Aggarwal "Design of A Novel Reconfigurable Fractal Antenna for Multi-Band Application", ISSN: 2005-4238 IJAST 2014

9. Changying Wu ,Zhou Yang1, Yusheng Li1,Yuan Zhang Yevhen Yashchyshyn "Methodology to Reduce the Number of Switches in Frequency Reconfigurable Antennas with Massive Switches", 2018.2812139, IEEE Acces

10. P. Satish Rama Chowdary , A. Mallikarjuna Prasad , P. Mallikarjuna Rao •,Jaume Anguera "Design and Performance Study of Sierpinski Fractal Based Patch Antennas for Multiband and Miniaturization Characteristics", New York 2015.
11. G. Christodoulou, Y. Tawk, S. A. Lane, and S. R. Erwin, "Reconfigurable antennas for wireless and space applications," Proc. IEEE, vol. 100, no. 7, pp. 2250–2261, Jul. 2012.
12. P. K. Li, Z. H. Shao, Q. Wang and Y. J. Cheng, "Frequency- and Pattern-Reconfigurable Antenna for Multistandard Wireless Applications," in IEEE Antennas and Wireless Propagation Letters, vol. 14, no.1, pp. 333-336, 2015.
13. Dr. Yogesh Bhomia1, Dr.Vipin Gupta2, Arushi Bhardwaj3, Nasreen Akhtar4 "To Design and Simulate Microstrip Patch Antenna by Line Feed ", 978-1-5386-0872-2/17 2017 IEEE
14. S. Nikolaou, N. D. Kingsley, G. E. Ponchak, J. Papapolymerou, and M. M. Tentzeris, ''UWB elliptical monopoles with a reconfigurable band notch using MEMS switches actuated without bias lines,'' IEEE Trans. Antennas Propag., vol. 57, no. 8, pp. 2242–2251, Aug. 2009.