Bulletin of the *Transilvania* University of Braşov • Vol. 13 (62) No. 1 - 2020
Series I: Engineering Sciences
https://doi.org/10.31926/but.ens.2020.13.62.1.6

OPTIMIZED MULTIBAND MINKOWSKI SHAPED FRACTAL ANTENNA FOR MIMO APPLICATION

N. SHARMA [1] K.K. SHARMA [1] H. MONGA [2]

Abstract: *A new optimized multiband Minkowski shaped fractal antenna is designed for multiple inputs a multiple output (MIMO) system has resonant frequency 2.45-2.48 GHz. Fractal antenna designed for first and for optimized dimensions using the Minkowski curve on micro strip patch boundaries. Electromagnetic tool IE3D is used using for simulation of the proposed antenna design. The antenna proposed in this article reduced the size of antenna by etched boundary of patch using Minkowski shaped fractal. Proposed antenna gives results for ISM band having high gain (>7.0 dBi), return loss values below -20 dB and radiation efficiency is >80%. A Optimized fractal antenna resonate at ISM band having high directional antenna for MIMO System.*

Key words: *Multiband, Microstrip patch antenna, Minkowski shape, Fractal antenna, MIMO.*

1. Introduction

The communication systems now days are moving towards wireless media. The increasing demand of wireless communication have resulted in increased thrust towards designing antennas that are lower in cost and squeezed size. Also, the designs need to satisfy the necessity of a modest radiating element, optimum performance and trouble-free fabrication [1]. The most optimum performance is dependent on criteria of selection of size and shape of antenna element. Various shapes have been proposed in the literature for deigning as per the requirements of applications. One of the alternative shapes which possess advantages is 'Fractal' geometry used for patch antennas [2]. Fractal is the word derived from Latin having meaning 'broken into segments. Fractals include numerous geometries like Hilbert curve, Minkowski loop, Sierpinski gasket, Koch snowflake, Giusepe piano and Sierpinski rug [3], [6]. Since the fractals have self-similarity and space filling characteristics, the fractals have merged as an optimal alternative to antenna design. Such properties support wider band operations and multiband operations, resulting in an overall size reduction. It is

[1] Chandigarh University, Punjab.
[2] Dept. of ECE, JNGEC, Sundernagar.

therefore possible to manufacture fractals in a smaller space [4], [7]. As far as the research moves, different structures have been designed by changing either the shape or the size of two parameters [5]. The patch antenna's multiband response is modified by integrating the patch antenna fractal. On patch ground, a fractal antenna created with the FR4 substratum by a Sierpinski carpet resulted in a reduction in the form of antenna [9], [11].

2. Antenna Design

For Antenna design: Some basic antenna-related parameters are resonant frequency (f_r), dielectric constant (ε_r) and substrate thickness or height. The proposed 2.45 GHz antenna frequency is selected because it is an open source frequency band undergoes low atmospheric attenuation and is used in MIMO System, WLAN, RFID and Bluetooth and other wireless applications. For this substratum, the dielectric content is RT-duriod with a dielectric constant of 2.2 and a failure tangent of 3.175 mm is 0.0009 [18]. Using the transmission line model [14], [17] the length and width of the micro strip patch was calculated.

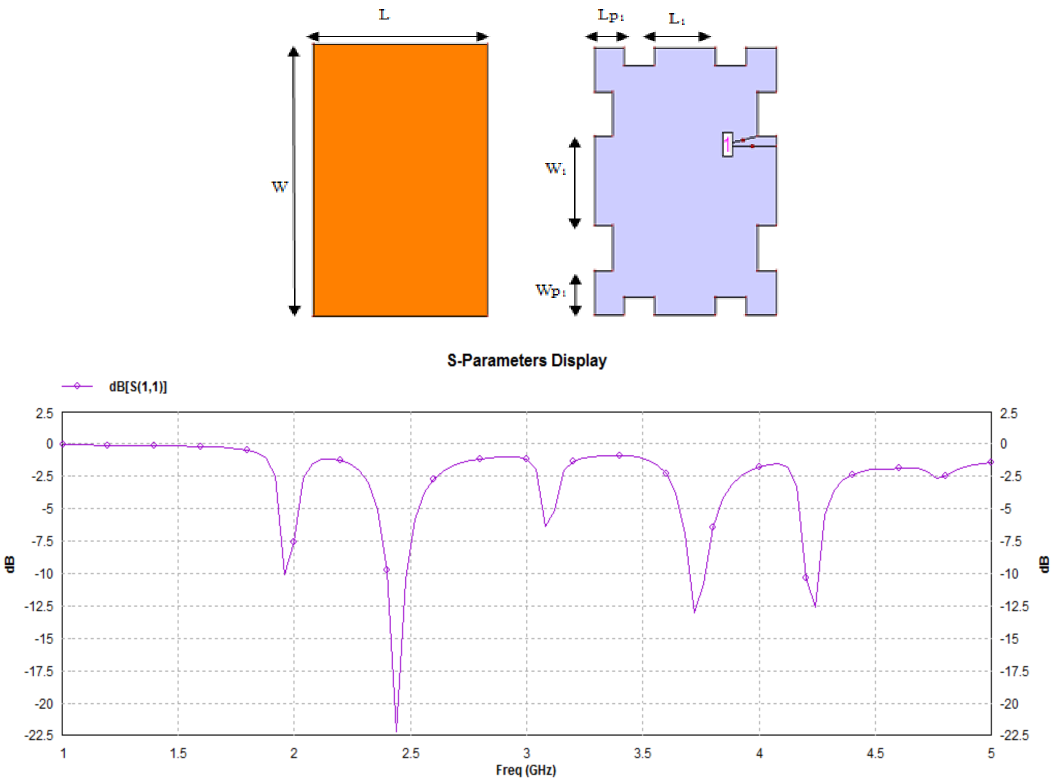

Fig. 1. *The initial generator model for fractal patch antenna creation*
(*a*) *0th iteration* (*b*) *1st iteration with coaxial feed* (*c*) *Simulated loss of return for the 1st Minkowski fractal antenna iteration*

The calculated dimension of micro strip patch [15] is 39.4×48.4 mm^2. At the patch boundaries, which are an initiator, the first iteration structure designed to reduce the sides of the generator used Minkowski curve. Figure 1 shows the generator model for creating fractal and a first iteration by its generating. Initially, the value of Lp_1 and Wp_1 is 1/6th of the values of L and W and values of L_1 and W_1 is 2 Lp_1 and 2 Wp_1. The value of Lp_2 and Wp_2 is ½ of the Lp_1 and Wp_1.

3. Results and Discussions

The simulation of the proposed antenna is done in IE3D software which is based on method of moment. Antenna is fed by coaxial probe feed for input to the antenna structure as illustrated in Figure 1(b). Figure 1(c) shows the return loss values for 1st iteration Minkowski loop fractal antenna. It resonances at four frequencies and the value of return loss for different frequency bands is below –10 dB means reducing losses, for 2.44 GHz value is –21.7656 and has a high bandwidth. The gain of the antenna is also high means it behaves as a directional antenna as shown in Figure 6(a). The characteristics impedance (Z_c) of the simulated antenna is 50 ohm.

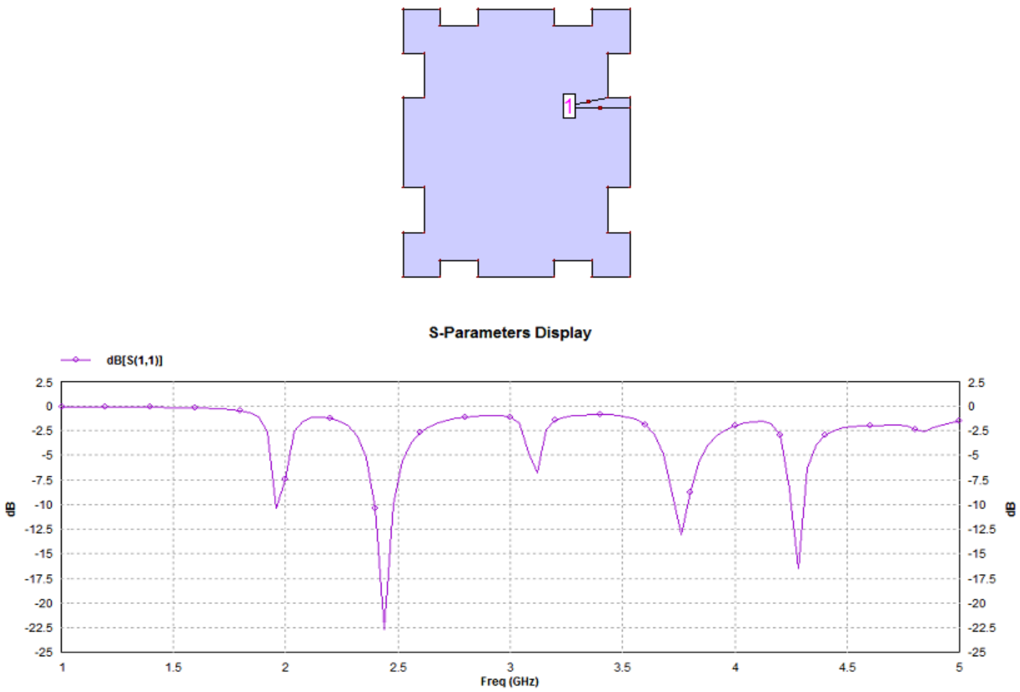

Fig. 2. (*a*) *Antenna structure with optimized dimensions of Minkowski loop;*
(*b*) *Simulated return loss for modified structure of Minkowski fractal antenna*

The 1^{st} iteration used Minkowski loop at the boundaries of the patch and the values of Lp_1, Wp_1 and Lp_2, Wp_2 used are 6.5666, 8.0566 and 3.2833, 4.0333 mm. After optimizing the value of Lp2 and Wp2 we take values to be respectively 3.00, 3.75 and the antenna structure is modified by reducing the length and width of the Minkowski loop. Proposed shape of modified antenna with feed point for 1^{st} iteration is given in Figure 2 and the simulated parameters are studied.

Obtained return loss value for 2.44 GHz is –22.131 dB as shown in Figure 2(b). Gain, bandwidth and antenna efficiency of modified structure antenna is also high; values are given in Table 1 below.

From the Table 1, we optimized the value of length and width (dimensions) for increased return loss values, bandwidth, gain, and radiation efficiency. Accordingly design considerations may help in future optimized designing/selection of fractal antenna.

Table 1

Comparison of simulated parameters for 1^{st} and optimized dimensions of Minkowski shape fractal antenna

Simulation parameters	**Resonant Frequencies (GHz)**							
	1^{st} Iteration				**Optimized Dimensions of Fractal Antenna**			
	1.96	2.44	3.72	4.23	1.96	2.44	3.76	4.27
Return loss (-) s_{11} (dB)	10.04	21.7	12.7	12.5	10.2	21.9	12.9	16.3
Gain (dBi)	4.44	5.4	5.85	3.03	6.38	7.03	5.60	4.06
VSWR	1.92	1.19	1.64	1.61	1.88	1.18	1.58	1.49
Radiation efficiency %	85.8	83.8	59.3	46.2	87.3	85.2	57.0	45.9
Bandwidth (MHz)	-	80	60	60	-	86	61	60

4. Conclusion

We have presented /obtained optimum antenna gain, which means that it functions like a directional antenna and radiates in a particular direction and has a high efficiency of conversion. MIMO system and antenna system, we need high directionality, high bandwidth and compact antenna. An optimized Minkowski shaped fractal antenna designed and simulated for 2.45 GHz, it resonates at four frequencies and behaves like a multiband antenna that fulfill requirement for MIMO System. For MIMO applications as well as for WLAN and RFID, the proposed antenna can be used.

Acknowledgements

We acknowledge the research facility available at JN Government Engineering College & Chandigarh University.

References

1. Chen, C-L., Chong, M-L.: *A radio frequency identification application for car theft prevention in parking lot management systems.* In: International Journal of Communication Systems (2014), p. 2481-2496.
2. Bani Hani, R.M., Ijjeh, A.A.: *A survey on LEACH-based energy aware protocols for wireless sensor networks*. In: J. Commun. **8** (2013) No. 3, p. 192-205.
3. Hung, C-L., Weng, W-C.: *An H-fractal antenna for multiband applications*. In: IEEE Antenna and Wireless Propagation Letters **13** (2014), p. 1705-1708.
4. Kumar, Y., Singh S.: *A compact multiband hybrid fractal antenna for multistandard mobile wireless application*. In: Wireless Personal Communication (2015), p. 55-67.
5. Song, X. Wang, Zhang, D.: *Extended AODV routing method based on distributed minimum transmission (DMT) for WSN.* In: AEU - Int. J. Electron. Commun. **69** (2015) No. 1, p. 371-381.
6. Balakrishnan, H., Chandrakasan, A., Heinzelman, W.R.: *Energy-Efficient Communication Protocol for Wireless Micro sensor Networks*, 2000
7. Pal, A., Vinoy, K.J.: *Dual-frequency characteristics of Minkowski - square ring antennas*. In: IET Microwave Antennas Propagation **4** (2010), p. 219-224.
8. Aseri, T.C., Kumar, D., Patel, R.B.: *EEHC: Energy efficient heterogeneous clustered scheme for wireless sensor networks*. In: Comput. Commun. **32** (2009), No. 4, p. 662-667.
9. Kang Sang, H., Nguyen Thinh: *Distance Based Thresholds for Cluster Head Selection in Wireless Sensor Networks*. In: IEEE Communications Letters **16** (2012), No. 9.
10. Kumar, D.: *Performance analysis of energy efficient clustering protocols for maximising lifetime of wireless sensor networks*. In: IET Wireless Sensor Systems **4** (2014) Issue 1.
11. Chu, Q.X., Mao, C.X.: *Compact Co radiator UWB-MIMO Antenna with Dual Polarization*. In: IEEE Transactions on Antennas and Propagation **62** (2014) No. 9, p. 4474-4480.
12. Mohan, A., Yadav, S.: *A Compact Koch Fractal UWB MIMO Antenna with WLAN Band-Rejection*. In: IEEE Antennas and Wireless Propagation Letters **14** (2015), p. 1565-1568.
13. Mehdi, T., Yousef, S., Kavian, S.S.: *SEECH: Scalable Energy Efficient Clustering Hierarchy Protocol in Wireless Sensor Networks*. In: IEEE Sensors Journal **14** (2014) Issue 11.
14. Monga, H.: *DNA and LCG Based Security Key Generation Algorithm.* In: Pertanika J. Sci. & Technol. **25(14)** (2018), p. 1369-1382.
15. Monga, H.: *I-LEACH Protocol for Wireless Sensor Ne*. In: International Journal of Multimedia and Ubiquitous Engineering **11(08)** (2018), p. 279-292.
16. Monga, H.: *Analytical Design, Simulation & Evaluation of Proposed OCDMA with Message Priority Fast Routing Codes*. In: National Academy Science Letters **37** (2014), p. 509-512.

17. Behera, S.K. , Choukiker, Y.K., Sharma, S.K.: *Hybrid Fractal Shape Planar Monopole Antenna Covering Multiband Wireless Communications with MIMO Implementation for Handheld Mobile Devices*. In: IEEE Transactions on Antennas and Propagation **62** (2014), p. 1483-1488.
18. Dhaliwal, B., Sharma, N.: *A new triple band hybrid fractal boundary antenna.* In: IEEE International Conference on Recent Trends in Electronics, Information and Communication Technology (2016).