

A multiband double square slot antenna with fractal geometry

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Abstract

A multiband double square loop antenna with fractal concept is proposed. The design is based on an initial model of fractal geometry and a double square slot antenna structure. The initial model of fractal geometry influences to the second frequency band and it will be carefully investigated. The radiation patterns of the proposed antenna are still similarly to bidirectional radiation pattern. The properties of the antenna such as return losses, radiation pattern and gain have been carried out via numerical simulation and measurement.

1. INTRODUCTION

Recently, the rapid increase of wireless communications leads to a large demand in designing of multiband antenna. There are different configurations used for multiband antennas. The fractal geometry concept is a special technique used to design multiband antennas [1-2]. For instance, Sierpinski gasket [3], Multiple Ring [4], Hexagonal Fractal [5], and circular fractal slot antenna [6] are applied to create the multiband antennas. Especially, the fractal antenna based on Sierpinski gasket is a prime ideal of designing for multiband operation.

In this work, we design a multiband antenna by applying Minkowski fractal concept to a large slot while the inner slot is a conventional structure. The generator model is applied to create the multiband double square slot antenna, shown in Fig.1. Simulation and experiment of the proposed antenna will be investigated. The effects of the generator model on each frequency operation band will be observed. The radiation patterns of the proposed antenna will be also evaluated. The details of designing, simulation and testing will be discussed in following sections.

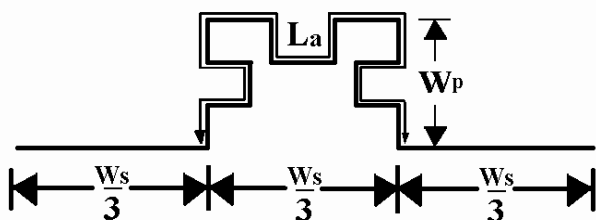


Fig. 1: The initial generator model for large slot of antenna.

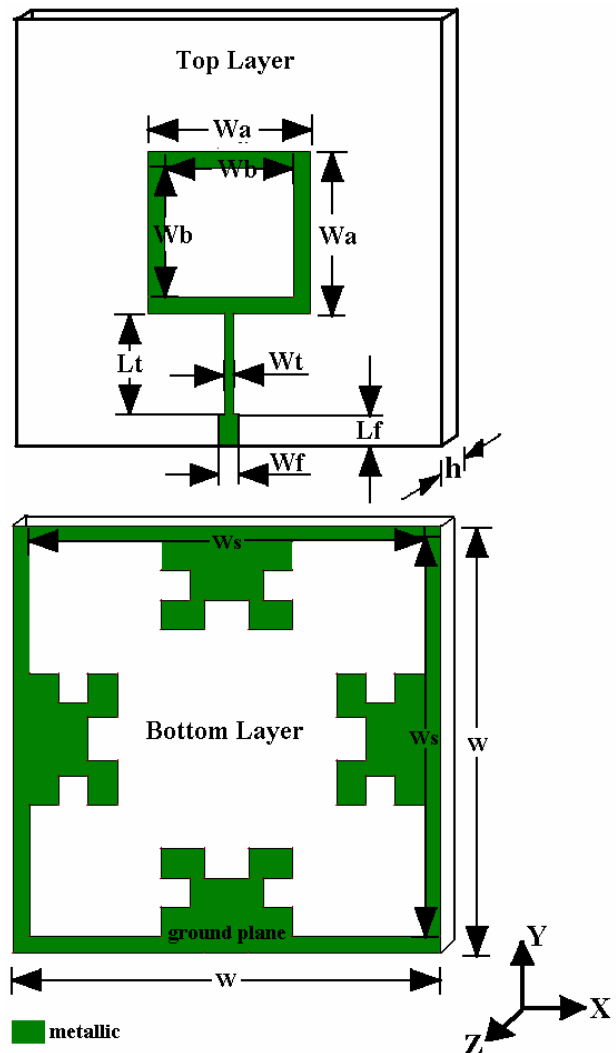


Fig. 2: The schematic diagram of the multiband double square loop antenna with fractal geometry.

2. ANTENNA DESIGN

The proposed multiband antenna in this paper is modified from the fractal ground slot antenna [7]. The height of initial

generator model shown in Fig. 1 varies with W_p . Usually, W_p is smaller than $W_s/3$ and the iteration factor is [8]

$$\eta = \frac{W_p}{W_s/3}; \quad 0 < \eta < 1 \quad (1)$$

In the paper, we use the iteration factor $\eta = 0.66$. The multiband double square slot antenna with fractal geometry is created by the initial model that generates each side of large square slot antenna. The antenna is fed by microstrip line to a small square slot antenna as shown in Fig.2.

The antennas are fabricated on a 1.6 mm thickness FR4 substrate with the relative permittivity ϵ_r of 4.4. The total size of proposed antenna is 88x88 mm. A 50 Ω SMA connector is used to feed the antenna at the microstrip line of small square slot antenna. Due to the proposed antenna is too complicated to calculate by using analytical technique, the simulation software IE3D, a 3-D full wave electromagnetic package by Zeland, is applied to efficiently analyze the characteristic of proposed antenna such as return loss, gain and radiation pattern. The antennas are optimized, resulting in following parameters: $h = 1.6$ mm, $W_p = 18.08$ mm, $W_a = 33.49$ mm, $W_b = 26.56$ mm, $W = 88$ mm, $W_s = 81.40$ mm, $W_t = 1.93$ mm, $W_f = 3.46$ mm, $L_t = 20.75$ mm and $L_f = 6.49$ mm. The antenna prototypes with different values of L_a are shown in Table 1. An example of fabricated antenna is depicted in Fig.3.

3. SIMULATION AND EXPERIMENTAL RESULTS

The simulated and measured return losses are depicted in Figs.4 (a) and (b). As it can be observed from this figure, the simulated and measured results are similar with each other. The return losses and resonant frequencies of all antennas are summarized in table 2. It can be also seen that the second resonant frequencies of simulated and measured results are shifted to lower frequency as L_a increased. For the first and third resonant frequencies of both results alter a little. It means that L_a influences on the second resonant frequency.

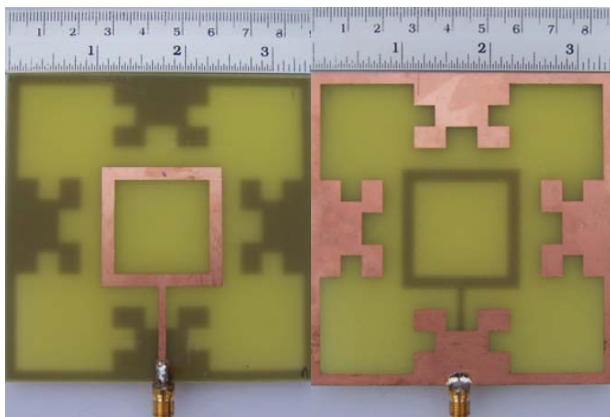


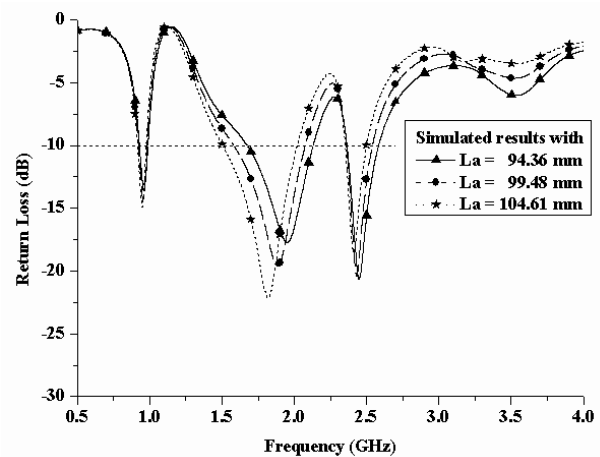
Fig.3. Photograph of the proposed antenna when $L_a = 99.48$ mm.

TABLE 1: PARAMETER OF DIFFERENT ANTENNAS

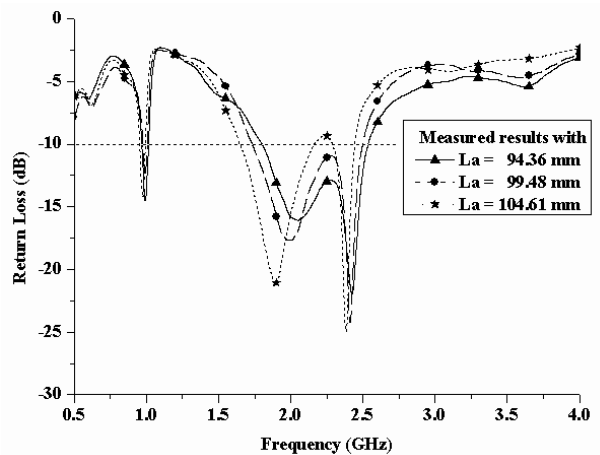
Parameters	Antenna 1	Antenna 2	Antenna 3
L_a (mm)	94.36	99.48	104.61

TABLE 2: RESONANT FREQUENCY AND RETURN LOSS RESULTS OF DIFFERENT ANTENNAS

Measured results		Band	Antenna 1	Antenna 2	Antenna 3
Resonant frequency (GHz)	Sim	1 st	0.96	0.95	0.95
		2 nd	1.96	1.88	1.82
		3 rd	2.45	2.43	2.41
	Meas	1 st	0.99	0.99	0.97
		2 nd	2.07	1.97	1.88
		3 rd	2.42	2.41	2.40
Return loss (dB)	Sim	1 st	-13.88	-14.21	-15.2
		2 nd	-17.74	-19.57	-22.15
		3 rd	-20.77	-20.58	-18.66
	Meas	1 st	-16.05	-13.99	-16.11
		2 nd	-16.11	-17.66	-21.24
		3 rd	-22.58	-25.77	-26.02



(a)



(b)

Fig.4: Return losses of the proposed antennas with $L_a = 94.36$ mm, 99.48 mm and 104.61 mm: (a) simulated results and (b) measured results.

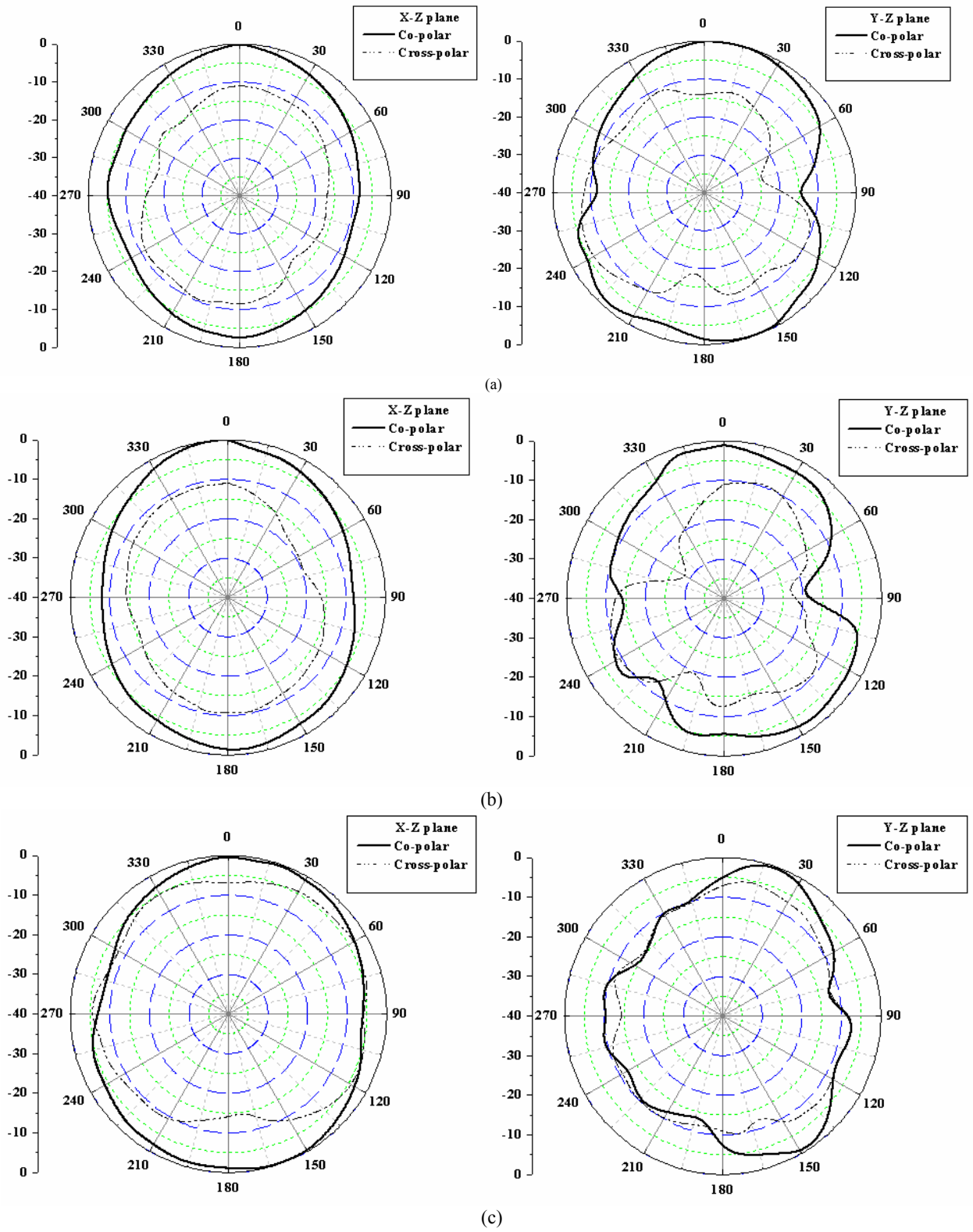


Fig.5: Measured radiation patterns with $L_a = 99.48$ mm at (a) 0.99 GHz, (b) 1.97 GHz and (c) 2.40 GHz.

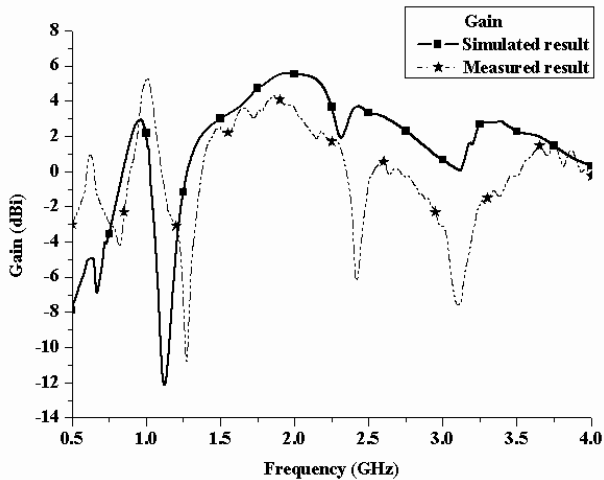


Fig.6: Simulated and measured gain of the proposed antenna with $L_a = 99.48$ mm.

Figs.5 (a), (b) and (c) depict the measured radiation patterns with $L_a = 99.48$ mm. As we can see that the measured radiation patterns are bidirectional. At the first and second resonance frequencies of 0.99 and 1.97 GHz, respectively, the maximum gains of radiation patterns in Y-Z plane are approximately occurred at 0 and 180 degrees. For the third resonant frequency of 2.40 GHz, the maximum gain of radiation pattern in Y-Z plane is approximately occurred at 30 and 150 degrees. Fig.6 shows the simulated and measured gain as the frequency varied. The average gain of the simulated and measured results is about 2 dBi at the resonant frequency.

4. CONCLUSION

In this paper, the multiband doubled square slot antenna with fractal geometry has been investigated. From the measured results, the proposed antenna are appropriated to apply for some mobile communication systems, such as DCS 1800 (1710-1880 MHz), DCS 1900 (1850-1990 MHz), UMTS (1920-2170 MHz) and WLAN (2400-2483 MHz). We can appropriately adjust the L_a in order to alter the second resonant frequency to support any mobile communication frequency band. The suitable value of L_a should be between 99.48 mm and 104.61 mm. For the further task, the first resonant frequency should be improved to the wider a frequency range for supporting the frequency band of GSM 900 (880 – 960 MHz).

REFERENCES

- [1] D.H. Werner and S. Ganguly, "An overview of fractal antenna engineering research," *IEEE Transactions Antenna & Propagation*, vol. 45, pp. 38-57, Feb 2003.
- [2] J.P. Gianvittorio and Y. Rahmat-Samii, "Fractal Antenna: A novel antenna miniaturization technique and application," *IEEE Transaction Antenna & Propagation*, vol. 44, pp. 20-36, Feb 2002.
- [3] C. Borja and J. Romeu, "Multiband Sierpinski fractal patch antenna," *Antennas and Propagation Society International Symposium, IEEE*, vol. 3, pp. 1708-1711, July 2000.
- [4] C. T.P. Song, Peter S. Hall and H. Ghafouri-Shiraz, "Multiband multiple ring monopole antennas," *IEEE Transactions Antenna & Propagation*, vol. 51, pp. 722-729, Apr 2003.
- [5] Philip Tang and Parveen Wahid, "Hexagonal Fractal Multiband Antenna," *Antennas and Propagation Society International Symposium, IEEE*, vol. 4, pp. 554-557, June 2002.
- [6] Ji-Chyun Liu, Der-Chyuan Lou, Chin-Yen Liu, Ching-Yang Wu and Tai-Wei Soong, "Precise Determinations of the CPW-FED Circular fractal slot antenna," *Microwave and Optical Technology Letters*, vol. 48, pp. 1586-1592, Aug 2006.
- [7] Chatree Mahatthanajatuphat and Prayoot Akkaraekthalin, "A miniaturized fractal ground slot antenna for RFID," *Proceeding of the 21st ITC-CSCC*, vol. 3, pp. 505-508, July 2006.
- [8] Chatree Mahatthanajatuphat and Prayoot Akkaraekthalin, "An NP generator model for Minkowski fractal antenna," *Proceeding of the 3rd ECTI Conference*, vol. 2, pp. 749-752, May 2006.