International Journal of Electronic Devices and Networking

E-ISSN: 2708-4485
P-ISSN: 2708-4477
IJEDN 2021; 2(1): 15-18

www.electronicnetjournal.com
Received: 06-11-2020
Accepted: 08-12-2020

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An investigation of random fractal-notch antenna on a square patch geometry

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Abstract
Fractal antennas have been in use from early 80's. In this paper we design certain fractal notches in microstrip antenna which gives much improved antenna properties like gain, bandwidth, efficiency, reduced return losses, directivity and so on. Finally, a comparison with normal microstrip antenna without notch is made with fractal notched strip antenna. This can also be used for multiband applications since it covers many frequency bands.

Keywords: Fractal notch, radiation efficiency, multiband

1. Introduction
The word fractal was first introduced by B. Mandelbrot, who is the forefather of the fractal geometry. The term mainly originated from the word "fractus" which is Latin base, which literally means broken or irregularly fragmented of complex shapes. There are many fractal antennas in antenna world without actually knowing like spiral, helical, conical, biconical antenna and so on. These antennas are mainly used to cover multiband frequency and where antenna shape is a major constraint because 50-90% of its area can be reduced if we use fractals. Fractals are mirror image structures which repeats itself. The fractal shape usually repeats with different geometry which coincides with nature of desired frequency. There are many fractal geometries which came into idea from the nature and things around us. There are many standard fractals like tree, Koch, Minkowski, and Hilbert fractals which are mainly used while designing antennas. Fractals are almost present in even the real world of nature (snail shells, leaves on a tree, pine cones), that's why fractal antennas came into existence. Since fractal antennas have complex shapes and it mainly permits many electric current modes which are distinct in nature which will increase radiation. Hence a fractal antenna has very wide range of bandwidth and smaller size of antenna which is transportable and require very less area.

2. Design
2.1 Microstrip with strip fractals
In this a simple fractal notch is made in the center of micro strip antenna. It is mainly done to increase the radiation properties of antenna. When the fractal notch is not present the radiation pattern is not high and the antenna pattern direction is not much beam formed. These radiation properties are difficult to obtain using normal antennas and practically impossible. Hence, with fractal antennas we can obtain desired shape (small), Bandwidth, frequency etc. The square patch dimension is 14.8 mm x 10 mm. The notch is made of 10.2 x 6.6 mm. When coming to return loss with and without fractal notch it is better for antenna with fractal notch which is -22dB and without notch is -14dB coming to gain the gain of antenna without fractal is only 4dB and if we use fractal the gain is 6. 2dB. Efficiency is increased about 20%.

2.2 Microstrip with circular ring notch
The same shape is repeated in a limited size such that the total length of the antenna is increased to match, for example, half of the wavelength of the corresponding desired frequency. The square patch dimension is 14.8 mm x 10 mm. The notch is made of 10.2 x 6.6 mm. Instead of designing a fractal notch we introduce a simple circle of radius 3.3 mm. When coming to return loss with and without fractal notch it is better for antenna with fractal notch which is -28dB at two frequencies and without notch is -14dB. Coming to gain the gain of antenna without fractal is only 4dB and if we use fractal the gain is 6.8dB. Efficiency is increased about 20%. The main use of circular ring is it can cover two frequencies.

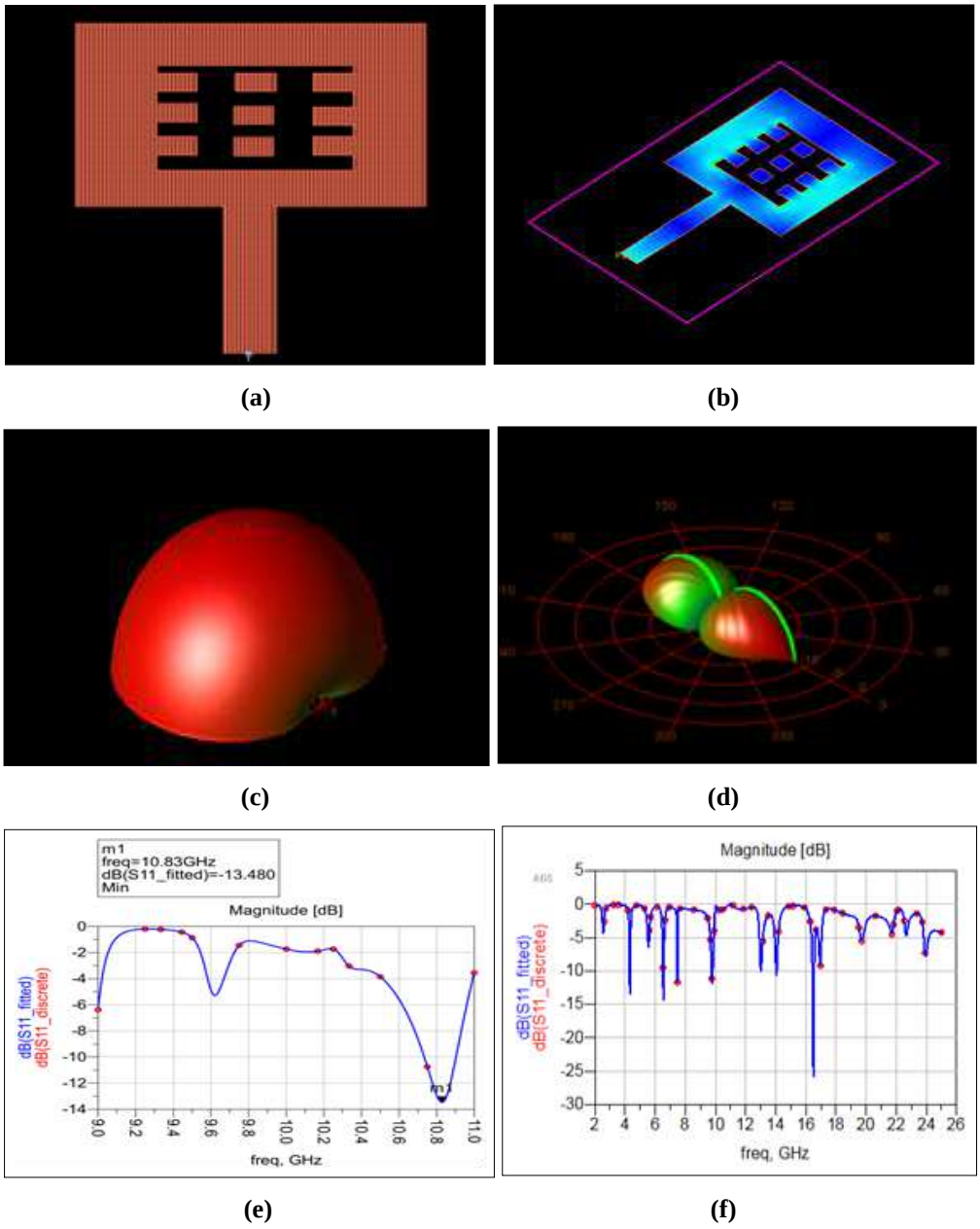
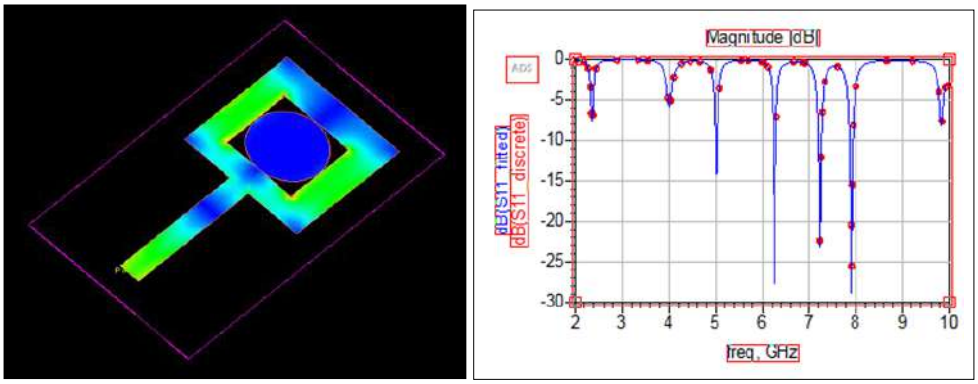


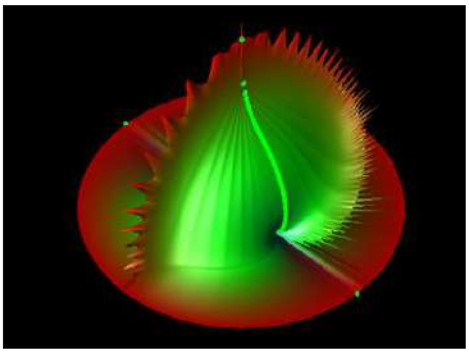
Fig 1: (a) Layout of fractal notch in a simple strip antenna, (b) 3D layout of fractal notch in a simple strip antenna, (c) Radiation pattern of non-fractal notch antenna, (d) Radiation pattern of fractal patch antenna, (e) Return loss for non-fractal notch antenna, (f) Return loss for non-fractal notch antenna

Table 1: Dimensions of fig 1

Patch	
Width w	14.8 mm
Length l	10 mm
98 Ω feedline (λ/4 transformer)	
Width w	0.214085 mm
Length l	5.690830 mm
Horizontal slot	Length: 6.8 mm Width: 0.8 mm
	Length: 6.8 mm Width: 1.4 mm
	Length: 6.8 mm Width: 1.2 mm
	Length: 6.8 mm Width: 2.2 mm
Vertical slots	Length: 6.8 mm Width: 1.8 mm
	Length: 6.8 mm Width: 1.8 mm



(a) **(b)**

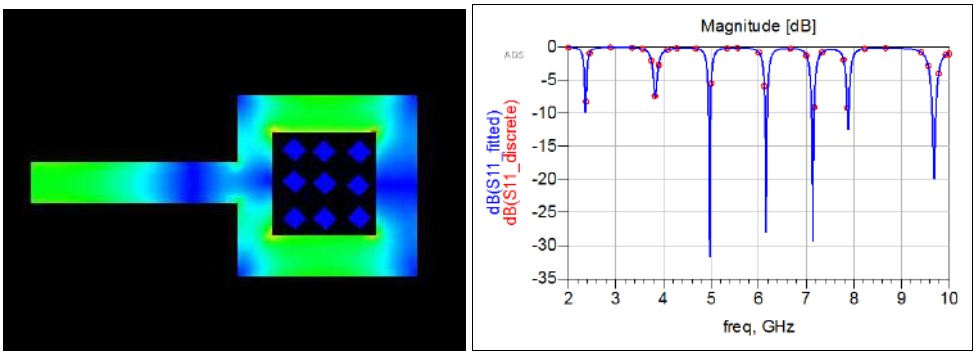


(c)

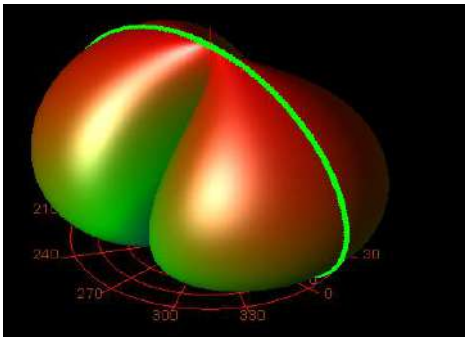
Fig 2: (a) 3D layout of fractal notch, (b) Return loss for circular notch antenna, (c) Axial ratio

2.3 Microstrip patch with diamond shape notch

In this instead of circular notch and strip fractal we use small random diamond shaped fractals inside the square notch. The square patch dimension is 14.8 mm x 10 mm. The notch is made of 10.2 x 6. 6 mm. Instead of designing a fractal notch and circle we use random diamond shape fractals. When coming to return loss with and without fractal notch it is better for antenna with fractal notch which is -33dB covering three frequencies and without notch is -14dB.coming to gain the gain of antenna without fractal is only 4dB and if we use fractal the gain is 7.1dB. Efficiency is increased about 40%.



(a) **(b)**



(c)

Fig 3: (a) 3D layout of fractal notch, (b) Return loss for diamond fractal antenna, (c) Radiation pattern

3. Result and Discussion

Table 2: Comparison of outputs

Antenna parameters	Gain (dB)	Efficiency (%)	Return loss (dB)
Without notch	4	40	-14
With fractal strip inside notch	6.2	60	-22
With circular ring inside notch	6.8	60	-28
With fractal diamond shape notch inside notch	7.1	80	-33

Thus, from the table it is clearly evident that diamond notch performance is better than all others. Also, the efficiency and gain is higher for all when compared to normal patch

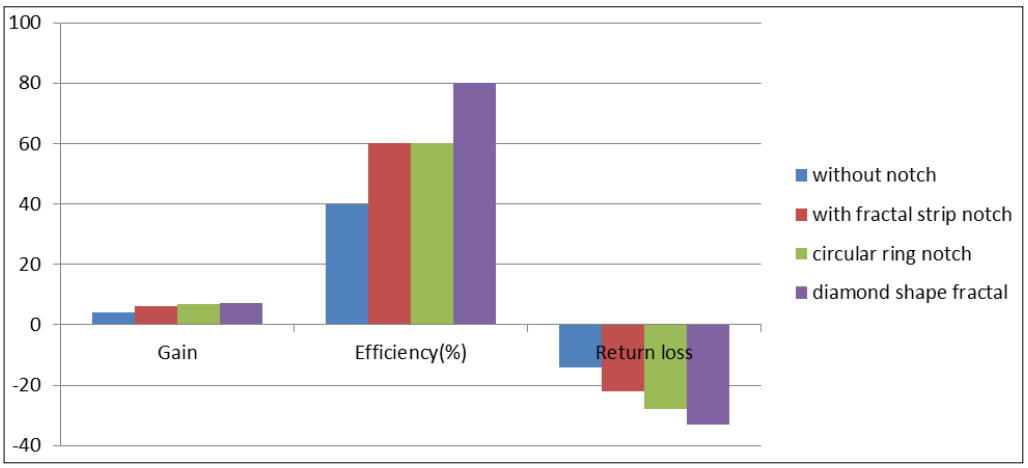


Fig 4: Graph for all parameters and comparison

4. Conclusion

Thus, it is clearly evident from the work that without fractal notch shapes the required gain, efficiency, bandwidth range, frequency cannot be achieved. Hence fractal antennas play an important role in improving antenna parameters and to reduce the size which will be used as many applications like portable bio-antennas, textile antennas etc.

5. References

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