The Study of Koch Fractal Applied to Isosceles Triangle Patch Antenna

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Abstract - This study presents a multiband isosceles triangle patch antenna applying Koch fractal. After applying first, second and third iteration on isosceles triangle patch antenna, it achieves at least 20% on area reduction. And the number of impendence matched resonate frequency bands increased with the fractal iterating.

***Index Terms* — Koch, Fractal, Patch antenna, Multiband.**

I. INTRODUCTION

Fractal means broken or irregular fragments, which describe a complex set of geometries that possess an inherent self-similarity or self affinity on other irregular structure. There are number of fractal shapes like Minlowski, Sierpinski, Koch curve, Hibert curve and I-shaped fractal or E-shaped fractal [1].

In recent years, the use of fractal on patch antenna has been widely studied. In these studies, a fractal patch antnna always accompanied with patch antenna area reduction and lower resonate frequencies. A Bow-tie patch antenna [2] applying Sierpinski fractal can not only gets the abovementioned advantages but also keep the high directivity at the same time. In [3], the Koch and the Sierpinski fractal are applied to a rectangle patch antenna. In this study, in addition to the abovementioned advantages, it also provide more than 50% bandwidth. The Minkowski fractal is used on a rectangle patch antenna as shown in [4]. In that study, except for the two advantages mentions above, it also reduced the radar cross-section. In [5], the I-shaped fractal are applied on a rectangle patch antenna. Its results reveal that aside from area compacting, a multi-band antenna are achieved.

In this study, a Koch fractal is selected and applied on an isosceles triangle patch antenna.

II. ANTENNA DESIGN

This Koch fractal patch antenna is design on a substrate which is height 1.6 mm, and its dielectric constant is 4.4. The size of the substrate is 50 mm*50 mm, and its bottom has a metal to be ground.

In the Fig. 1 (a), there is a normal 0^{th} iteration isosceles triangle, and its two side is 45.0694 mm, and the length of its baseline is 50 mm. In the Fig. 1 (b), it is the structure that after doing the 1^{st} iteration on the isosceles triangle in the Fig. 1 (a). The way is to cut the side length in to three equal parts which is 15.02313 mm, and draw a regular triangle inward to the center on the middle part, then remove the baseline of that regular triangle. Finally it turns out to a structure which its side has four equal small length long 15.02313 mm. Just like the Fig. 2 (b). And using the same way on the structure in Fig. 1 (b), the 2^{nd} iteration fractal structure in Fig. 1 (c) is completed. According to the same way, the 3^{rd} iteration fractal structure in Fig. 1 (d) is completed also.

In this study, the feed to the patch is using coaxial feed, and except the 0^{th} iteration fractal patch's feed point is downward 7 mm from the center, the others are all downward 9 mm from the center.

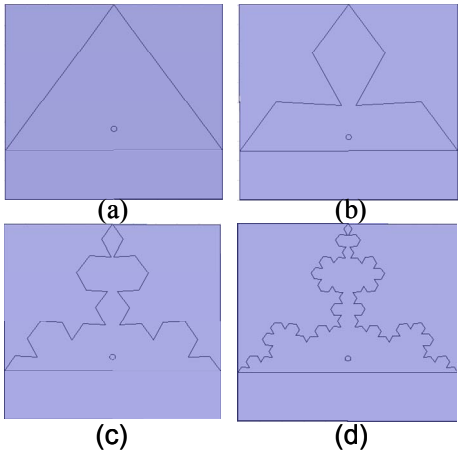


Fig. 1 schematics of the koch patch antenna

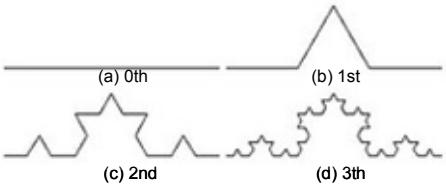


Fig. 2 Different iteration of Koch fractal

III. RESULTS AND DISCUSSION

There are the results that the isosceles triangle patch antenna through different iterations presenting in table I. And

having area reduction, resonate frequency, return loss, gain, and bandwidth. Fig. 3 are the results of return loss vs frequency of different iterations, From Fig. 3 and table I, the resonate frequencies that the 0th iteration isosceles triangle patch antenna has are 4.07 GHz, 7.41 GHz and 8.94 GHz. The total number are three. From Fig. and table I, after doing the first iteration, the resonate frequencies are 4.36 GHz, 5.28 GHz, 7.45 GHz and 8.71 GHz. A new resonate frequency appears, so the total resonate frequency number are increasing to four. From the Fig. 3, the resonate frequencies after the second iteration are 4.01 GHz, 4.72 GHz, 5.18 GHz, 6.96 GHz and 8.74 GHz. There is an another new resonate frequency turning up, so the total number are five. And from Fig. 3, After doing the third iteration, the total number of the resonate frequencies are still five. According to the results above, the conclusion is with the degree of the iteration increasing the number of the resonate frequencies increase also.

From the table I, it reveals that the area reduction can at least reach 20%. The value of 1st iteration is 20.85%, 30.12% for 2nd iteration and 34.23% for 3rd iteration. In the row of 2nd iteration, there is a negative gain -5.4282 dbi at 4.01GHz, and in the row of 3rd iteration, there is also a negative gain -6.7148 dbi. The radiation of the negative gains is shown in Fig. 4. This might arise from the small size of the substrate. At the base of -10 db return loss line, the bandwidth is mostly 100 MHz to 300 MHz, and in the row of 2nd iteration, there is a bandwidth about 500 MHz at 8.85 GHz.

Table I
COMPARSION TABLE OF DIFFERENT ITERATION

	Area reduction (%)	Resonant Frequency (GHz)	Loss return (db)	Gain (db)	BW (MHz)
0nd	0	4.07	-16.29	2.639	230
		7.41	-33.55	6.714	250
		8.94	-15.15	11.79	300
1st	20.85	4.38	-18.84	0.815	125
		5.28	-15.70	8.744	250
		7.45	-17.99	3.160	230
		8.71	-12.75	21.168	100
2nd	30.12	4.01	-26.56	-5.428	125
		4.72	-16.64	5.564	230
		5.18	-24.91	2.350	230
		6.94	-22.26	6.289	250
		8.85	-13.42	21.97	490
3nd	34.23	3.85	-26.21	-6.715	125
		4.58	-14.51	4.802	125
		5.09	-31.21	2.935	250
		6.82	-10.76	5.666	105
		8.49	-10.58	18.576	100

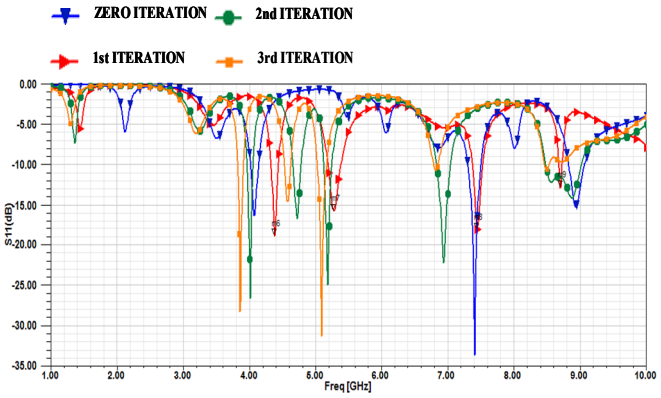
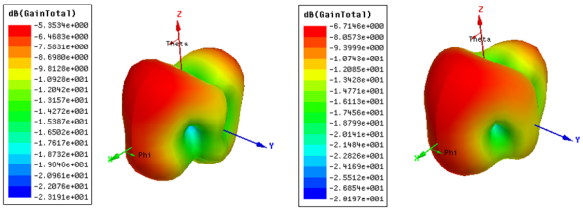


Fig. 3 Return loss Vs Frequency for Different Fractal Iterations.



(a) At 4.01GHz of 2nd iteration (b) At 3.86 GHz of 3rd iteration
Fig. 4 The radition of negative gain from different iteration

IV. CONCLUSION

The purpose of this study is to observe results from the different iterations of Koch fractal applying on isosceles triangle and analyze it. According to the discussion above, it conclude that the number of resonate frequency which having impendence matching increase with the fractal iterating. Becoming from three to five. In addition, it also achieve the advantage of area reduction. Reaching at least 20% above. But the patch antenna appears negative gain at 2nd iteration fractal and 3rd iteration fractal. Maybe it can be improved by adjust the substrate size. At last, the bandwidth is mostly narrow band. It is also a part that can be improve in the future.

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