A Novel Design of Fractal Patch Antenna for Navigation Applications

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***Abstract* -** In the modern world, there is different kind of antennas available for wireless communication. With the advancement in the antenna technology some system like military and commercial telecommunication system requires miniaturization, ultra wideband, multiband and cost effective antennas. Here a multiband fractal patch antenna has been obtained by applying fractal geometry and ring structure. By applying first iteration using FR4 substrate material, antenna resonated at 4.44 GHz, 4.80 GHz, 6.55 GHz, 7.34 GHz, and 8.24 GHz with the return loss achieved is -24.36 dB, -13.05 dB, -13.49 dB, -19.65 dB and -13.08 dB respectively. This antenna has maximum gain of 9.20 dB with bandwidth of approx. 600 MHz.

I. INTRODUCTION

With the tremendous advancements in wireless communications, there is an increasing demand for miniature, low-cost, easy-to- fabricate, multiband and wideband antennas for use in commercial communications systems. As a part of an effort to further enhance modern communications systems technology, researchers have been studying different approaches for creating novel and innovative antennas. The approach adopted in this paper combines fractal geometry and left-handed meta-material in order to achieve an antenna design suitable for several wireless applications.

Micro strip is the second generation antennas. It is a metallic patch, printed on thin grounded dielectric substrate using a process similar to lithography in which patterns are printed on the substrate while fabricating printed circuit boards or integrated circuit. The main advantages are its low weight and low cost. Narrow bandwidth and low efficiency are its main disadvantages.

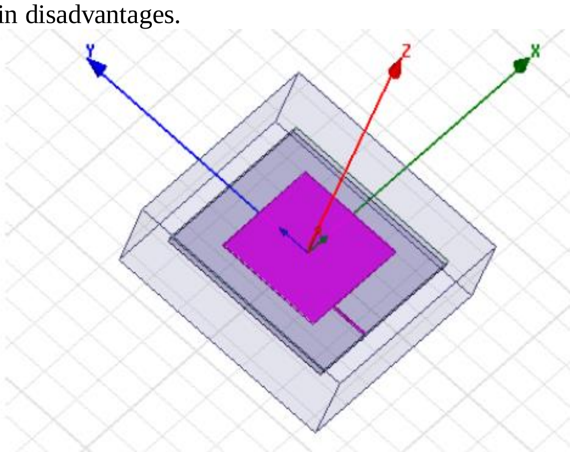


Figure1: Simple Micro-strip Antenna

Clouds, mountains, plant leaves and coastlines are the inspiration for fractal geometries [1]-[5]. It is essential to design antenna as compressed as achievable for some application. Fractal antenna has entered the view of many as a very promising solution. Fractal antenna [2] [4] is the best suitable radiating structure. In modern technology fractal antenna theory exist as a new area. Fractal geometry has self-similar and space filling property [3]. These pattern no doubt looks complex but because of their self-similarity are very simple geometry. Minkoski Island, Sierpinski gasket, Hilbert and Koch Snowflake, Sierpinski carpet, are the basic geometric pattern of fractal antennas. To provide feed to antenna there are different type of feeding techniques are used such as microstrip line [6], coaxial probe [7], coplanar waveguide [8] etc. Each feeding technique is used for different application purpose.

II. FRACTUAL GEOMETRY

There are various types of geometry used in fractal antenna that are discussed here.

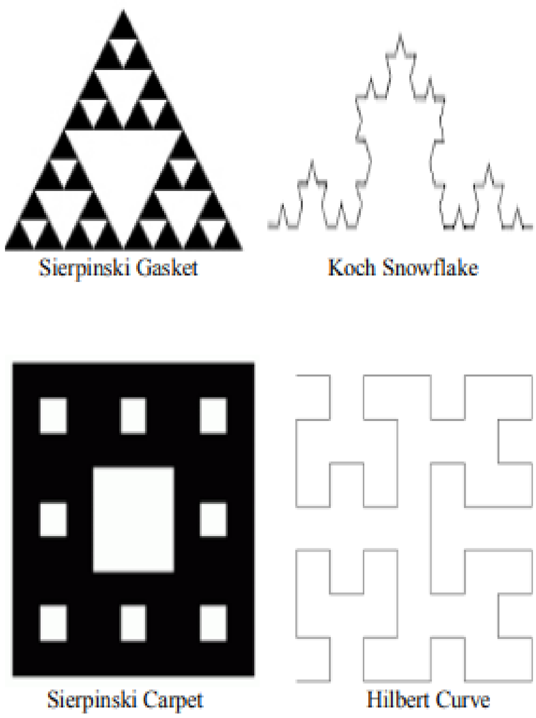


Figure2: Different kind of geometry used in fractal antenna [9] [15]

Sirepinski gasket - it is also called Sierpinski sieve. It is a fractal that has attractive fixed set with overall shape of equilateral triangles and subdivided recursively into smaller equilateral triangles.

Koch snowflake - the initiator for the Koch snowflake is an equilateral triangle. Then divide the line segment into three segments of equal length. After that draw the equilateral triangle by taking drawn line segment as its base and points outward. Remove the line segment that is the base of triangle made from the first line segment. The Koch curve originally described by Koch is constructed with only one of three sides of the original triangle. In other words, three Koch curves make a Koch snowflake.

Sirepinski carpet - in this technique a shape is subdividing into smaller copies of itself, removing one or more copies and continuing recursively can be extended to other shapes.

Hilbert curve - it is a continuous fractal space filling curve that fills the square. The beginning state is on the left. Hilbert designed his curve as connecting the centers of four sub squares, which made up a larger square. To begin three segments connect the four centers in an upside down U shape

III. PROPOSED WORK

The fractal antenna in communication or military applications has been an emerging research topic in the past few years. It is desirable for a single device to access the additional several services like GSM, CDMA, WCDMA, GPS, Wi-Fi, WI-MAX, UMTS, Bluetooth, 802.11a, and 802.11b bands or satellite communication bands. To facilitate this, the antenna should not just work on single frequency band but should operate with multiple bands. Fractal antennas can be used in this case which will work on multiband frequencies. Development of communication and integration circuit's technologies, size reduction and bandwidth broadening are becoming important design considerations for practical applications of fractal antenna. The limitation of microstrip patch antenna such as low power handling capability, low gain, and so fractal antenna may help to improve gain and bandwidth of antenna. The main objective of this paper is to Design a compact patch antenna using novel/modified fractal geometry and Optimizing the proposed antenna to cover multiple bands covering satellite communication bands like L, S, C, X etc.

IV. IMPLEMENTATION

Fig. 4.1 shows detailed dimensions of basic equilateral triangle patch antenna with the overall size of the substrate is 60 mm x 60 mm. The side of the equilateral triangle is a = 34 mm.

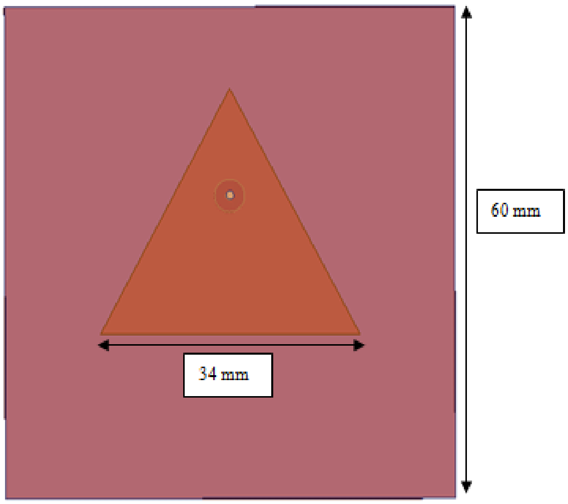


Figure3: Basic Equilateral Triangular patch Antenna designed in HFSS (0th Iteration)

The design specifications are given in the table below.

Table 1 Design Specification of basic patch antenna

Substrate Type	FR4
Dielectric Constant (ε_r)	4.4
Loss Tangent (δ)	0.02
Substrate Thickness (h)	1.6 mm

2nd Iteration of Koch Snowflake Geometry

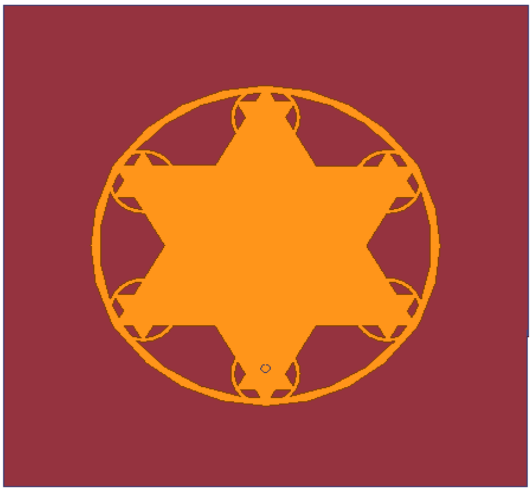


Figure 4: Proposed Fractal Antenna 2nd Iteration

Return Loss - Fig. 5 shows S11 parameters (return loss) for the basic triangular patch antenna with first resonance at 2.14 GHz, 3.35 GHz, 4.26 GHz, 4.62 GHz, 5.16 GHz, 5.46 GHz, and 6.91 GHz with the return loss achieved is -15.20 dB, -11.06 dB, -23.56 dB, -24.40 dB, -17.19 dB, -12.05 dB, and -16.77 dB respectively. The bandwidth of the antenna can be said to be those range of frequencies over which the return loss is less than -10 dB. The bandwidth at the resonant frequencies is 115 MHz, 60 MHz, 102 MHz, 139 MHz, 115 MHz, 102 MHz and 140 MHz respectively.

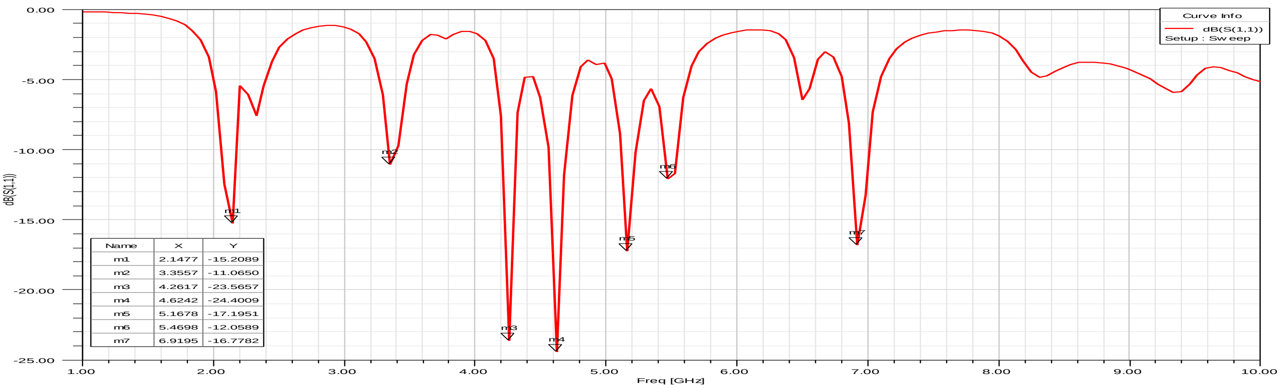
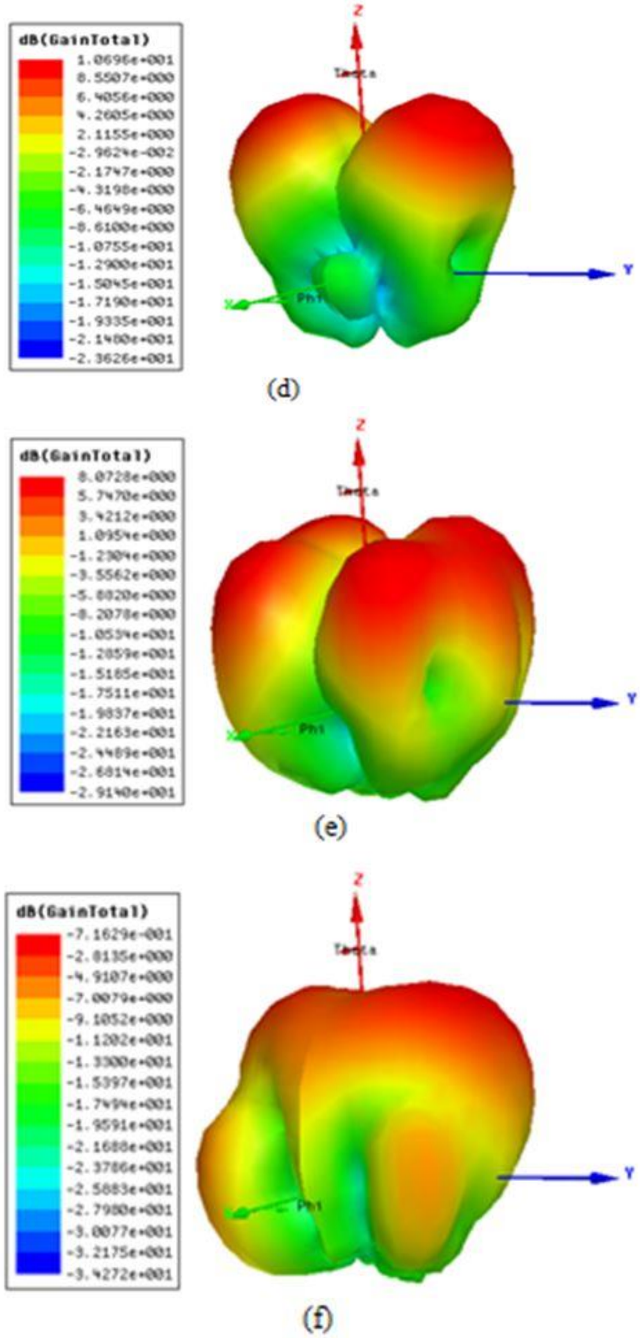
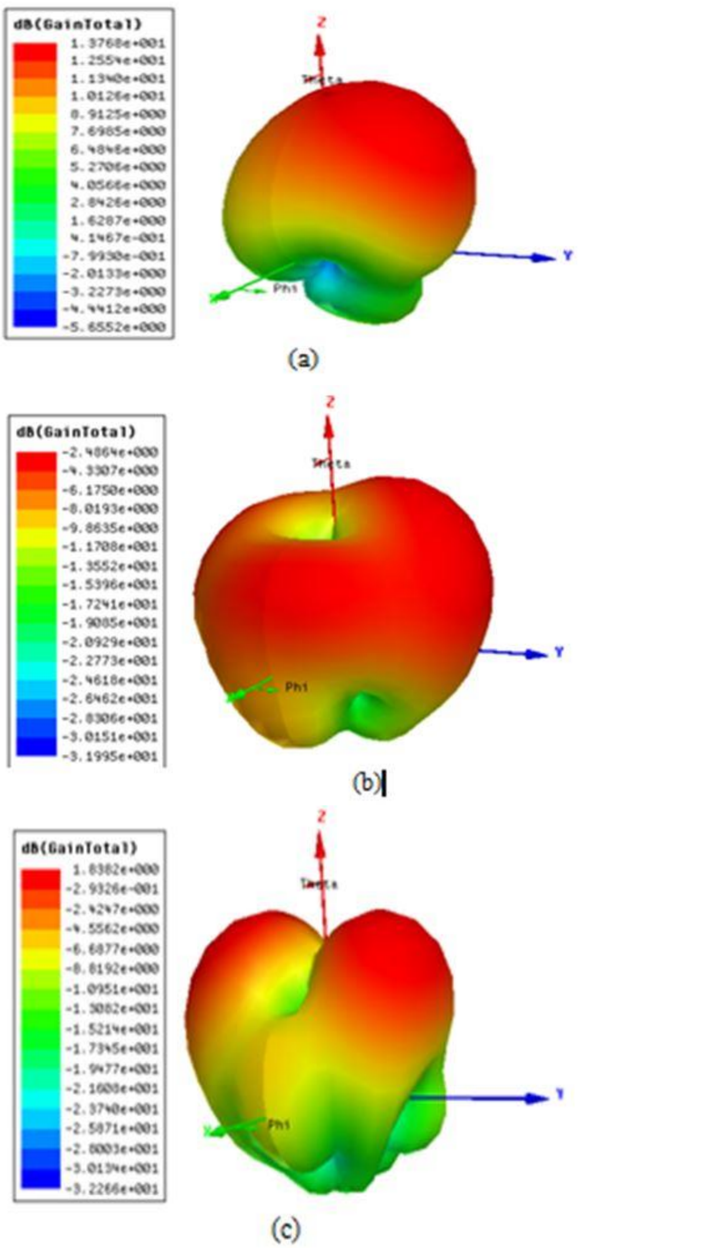


Figure 5: Simulated Return Loss S11 of Proposed Fractal Antenna (in dB)

Gain - The Gain plot in Fig.6 shows gain values at different resonant frequencies.





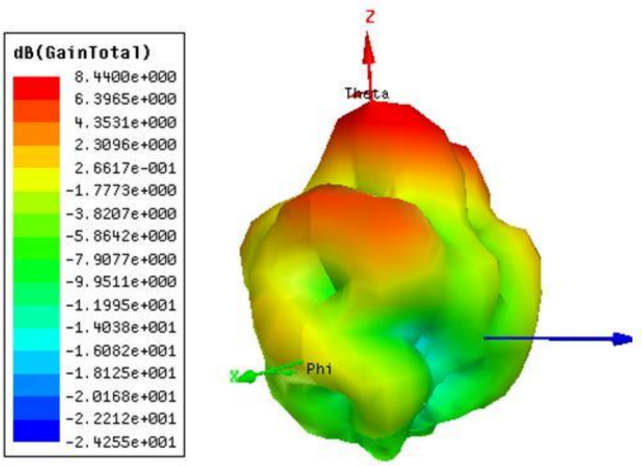
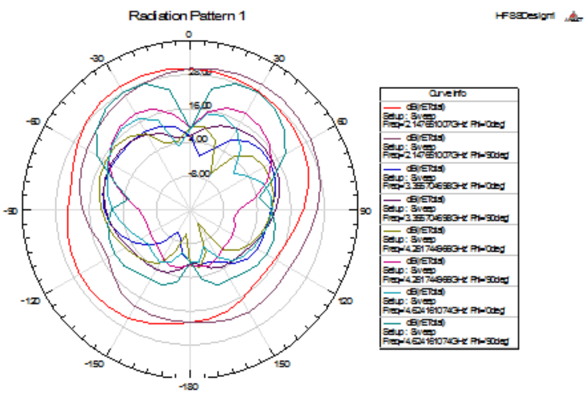
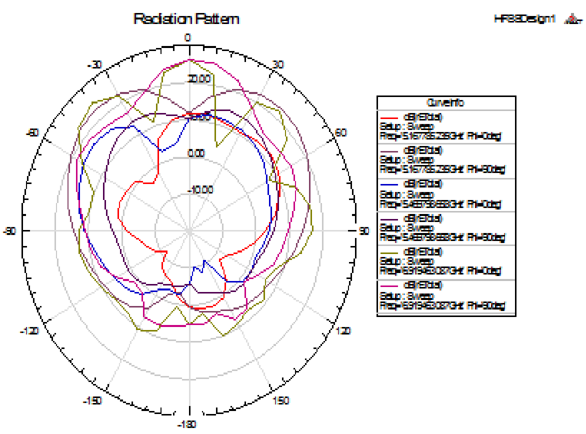


Figure 6: Simulated Gain of Triangular Patch Antenna at (a) 2.14 GHz (b) 3.35 GHz (c) 4.26 GHz (d) 4.62 GHz (e) 5.16 GHz (f) 5.46 GHz (g) 6.91 GHz GHz (3D view)

Radiation Pattern - From 2D plot view of radiation pattern as shown in Fig.7, it can be seen that at resonant frequencies radiation pattern obtained is Omni directional.



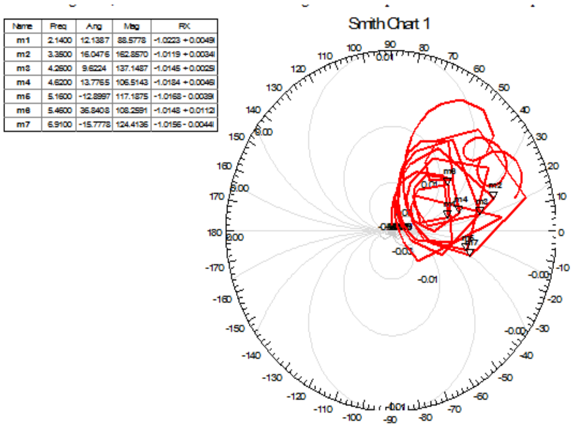
(a)



(b)

Figure 7: Radiation Pattern of the designed Antenna at (a) 2.14 GHz, 3.35 GHz, 4.26 GHz, 4.62 GHz (b) 5.16 GHz, 5.46 GHz, 6.91 GHz (2D view) for phi = 00 & 900

Smith Chart



Name	Freq	Ang	Mag	RX
m1	2.1400	12.1387	88.5778	-1.0223 + 0.0049i
m2	3.3500	16.0476	162.8570	-1.0119 + 0.0034i
m3	4.2600	9.6224	137.1487	-1.0145 + 0.0025i
m4	4.6200	13.7765	106.5143	-1.0184 + 0.0046i
m5	5.1600	-12.8997	117.1875	-1.0168 - 0.0039i
m6	5.4600	36.8408	108.2591	-1.0148 + 0.0112i
m7	6.9100	-15.7778	124.4136	-1.0156 - 0.0044i

Figure 8: Smith Chart of the designed Antenna (2nd Iteration)

From the Fig. 8, it can be observed that the magnitude of impedance at resonant frequencies.

V. CONCLUSION

In this thesis work, multiband fractal patch antenna has been obtained by applying fractal geometry and ring structure. The proposed geometry was based on Koch snowflakes fractal design. The proposed geometry was simulated in HFSS using FR4 as the substrate material. The 0th and 1st iterations of the design were compared minutely in terms of return loss, bandwidth, VSWR and gain. The designs are showing multiband performance ranging between 1 GHz to 10 GHz. There has been a considerable improvement in Gain in successively iteration. In terms of size the patch area has been also reduced when compared to simple rectangular patch using FR4 respectively.

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