Investigating Dielectric Materials for U-KOCH Micro-strip Antenna for Wireless Application

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Abstract: Low cost, low profile, small volumes of microstrip antenna have made their presence in real world application. A low-cost multiband Printed-Circuit-Board (PCB) antenna that employs Koch fractal geometry will be studied. The proposed antenna will be simulated using the Finite-Element Method for three different dielectric materials and the return loss is measured for each case. the antenna can cover the bands of several applications including 3G, Wi-Fi, Wi-MAX as well as a portion of the UWB range[2]. In this paper we have 3 iteration of the Koch Geometry with each geometry do have their own result. In this paper we have change the material in the 3rd iteration to note down the effect on the resonating frequency.
Keywords: Fractal Microstrip Antenna, Koch Fractal Antenna, FR4, Multiband.

INTRODUCTION:-

Micro-strip antenna was a simple antenna that consists of a radiated patch component, dielectric substrate and ground plane. The radiated patch and ground plane are thin layers of PEC or gold which is a good conductor. Each dielectric substrate has its own dielectric permittivity value. This permittivity influences the size of the antenna. Recent advancement in their design has attracted engineers to use them for commercial purpose. Their low cost, small size, and light weight are among some of their advantages[1]. These days these are commonly used in almost all wireless applications and are commercially available at low price. However, fractal antennas and its superset fractal electrodynamics is a state of affairs for research activity. To enhance the properties of the KOCH fractal antenna we have gone through the different-2 materials. Up to now in the previous paper there is utilization of material FR4 but using the same material we can go up to the two iteration only but to elaborate the concept from the iteration point of view we have use the material Roger duroid (5880), FR4 and Ceramics(Al2O3) to enhance the result up to the 2nd iteration. By using the material Roger duroid (5880) the return loss which were very high in case of the material FR4 are reduced appropriately to modify the design of the KOCH fractal antenna. The approach adopted for the design will combines fractal geometry and different dielectric materials to come up with a new antenna design suitable for several wireless applications. The fact that different wireless standards, such as UMTS, WLAN and Wi MAX, use different operation bands pushes the need for terminal antennas that are multiband and/ or wideband. The purposed antenna does have more than two operating frequencies with efficient return loss.

Fractal Antenna Engineering:-

Fractal antenna engineering is a swiftly evolving field that aims at developing a new class of antennas that are multiband, wideband and/or compact in size. A fractal is a self-repetitive geometry which is generated using an iterative process and whose parts have the same shape as the whole geometry but at different scales [3]. Accordingly, fractal based radiators are expected to operate similarly at multiple wavelengths and keep similar radiation parameters over several bands. They are the most commonly employed in the present era of antenna designing. Another property of fractal geometries, which makes them attractive candidates for use in the design of fractal antennas, is their space filling property[1]-[7]. This feature can be exploited to miniaturize classical antenna elements, such as dipoles and loops, and overcome some of the limitations of small antennas. The line that is used to represent the fractal geometry can meander in such a way that effectively fills the available space, leading to curves that are electrically long but compacted in a small physical space.

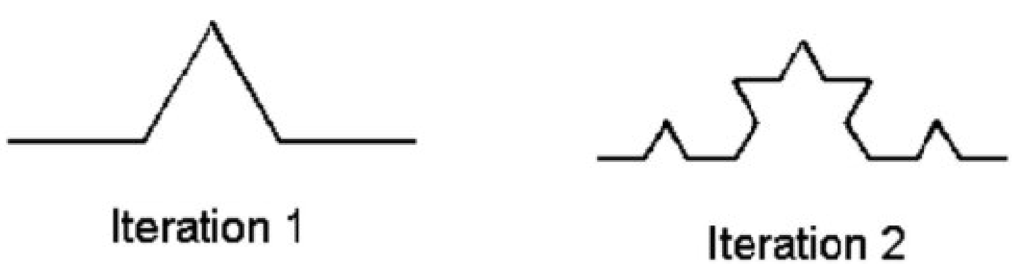

Fig 1. Shows the basic structures of the Koch geometry

Advantages of Fractal antenna over conventional antennas are

1. Multiband performance is at non-harmonic frequencies.
2. Improved Impedance, Improved SWR (standing wave ratio) performance on a reduced physical area when compared to non fractal Euclidean geometries.
3. Compressed resonant behaviour.
4. At higher frequencies the FEA is naturally broadband.
5. Polarization and phasing of FEAs also are possible.
6. In many cases, the use of fractal element antennas can simplify circuit design.
7. Reduced construction costs.
8. Improved reliability.

II. DESIGN MODEL

The antenna is fabricated on a 1.6 mm-thick FR4-epoxy substrate with dimensions 4cm×4.5cm is microstrip line fed and has a partial ground plane flushed with the feed line [2]. In this design we are using different dielectric materials for the substrate and results have been studied.

The width of antenna can be calculated as:

$$W=\frac{c}{2f_{\square}\sqrt{\frac{(\varepsilon_r-1)}{2}}}$$

The effective dielectric constant can be calculated by [4]:

$$\epsilon_{reff}=\frac{\epsilon_r+1}{2}+\frac{\epsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{\frac{1}{2}}$$

The effective length is (L_{eff}):

$$L_{eff}=\frac{c}{2f_{\square}\sqrt{\varepsilon_{reff}}}$$

The length extension is:

$$\Delta L=0.412h\frac{(\epsilon_r+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_r-0.258)\left(\frac{W}{h}+0.8\right)}$$

The calculation of actual length of patch:

$L=L_{eff}-2\Delta L$

Slot dimensions for antenna:

There are basically two rectangular shapes of slots inserted in the design having dimensions 1.2×5.28 and 1.2×6.7. They serve to increase in bandwidth and decrease in size of the antenna [5]-[6]. The length of microstrip feed is 20×2.5 and has a zigzag geometry with variation of 0.5mm at a step interval of 2.5mm.

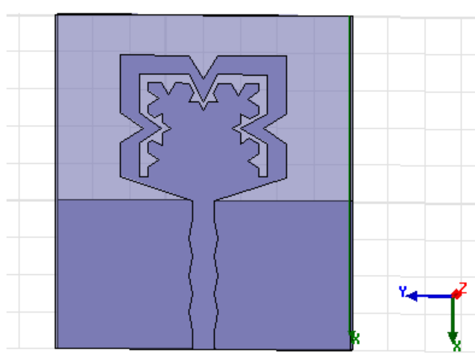

Fig 2. The design with first-iteration and second-iteration Koch fractals.

3.RESULTS AND DISCUSSION

The design is simulated with Ansoft HFSS which is EM Simulator based on Finite-Element Method [8]. The design with second-iteration Koch fractal geometry is simulated with different dielectric material as substrate material. The main purpose of using different dielectric material for the design is to investigate the antenna with multi-band operation with practical applicable operating frequency. The return loss for ceramics are shown in Fig 3. The resulting computed return loss for FR4 substrate are shown in Fig 4. The resulting return loss of all the three substrate materials are compared and applicable dielectric material selection for the proposed design are being concluded. The resulting return computed for Roger duroid are shown in Fig 6. Finally the radiation pattern are being computed with the final dielectric material. The electric field vector for patch are computed for the patch with Roger Duroid material.

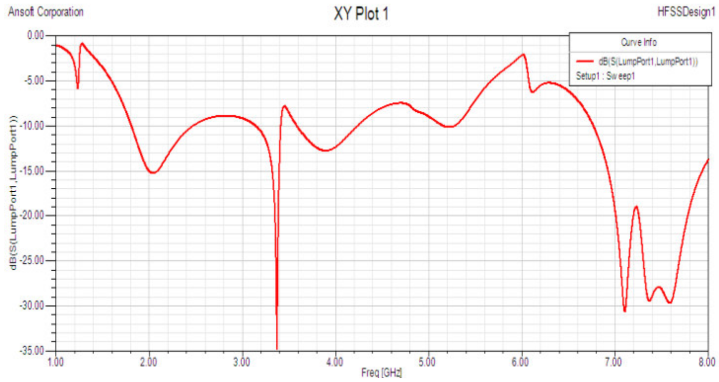

Fig 3. The return loss of Koch fractal antenna with Ceramics Substrate.

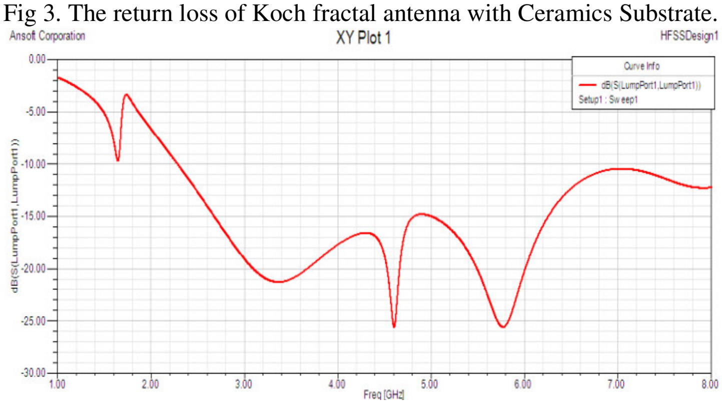

Fig 4. The return loss of Koch fractal antenna with FR4 Substrate.

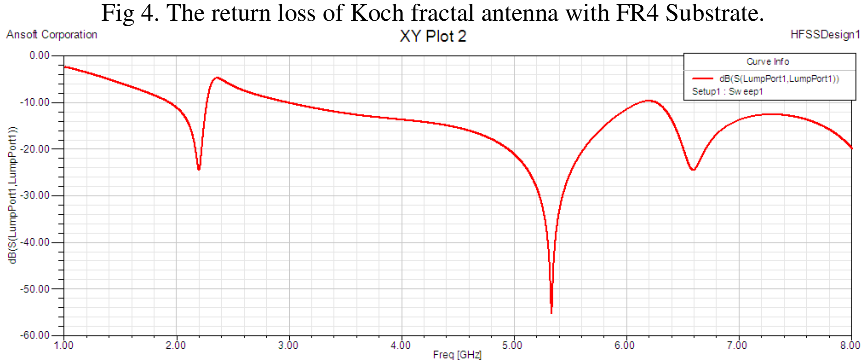

Fig 5. The return loss of Koch fractal antenna with Roger duroid 5880 Substrate.

Material	Freq(1)	Freq(2)	Freq(3)	Min. return loss
Ceramics(Al2O3)	2.1(GHz)	3.3(GHz)	7.1(GHz)	-35 db
FR4	1.6(GHz)	4.4(GHz)	5.8(GHz)	-25 db
Roger5880	2.2(GHz)	5.25(GHz)	6.6(GHz)	-55 db

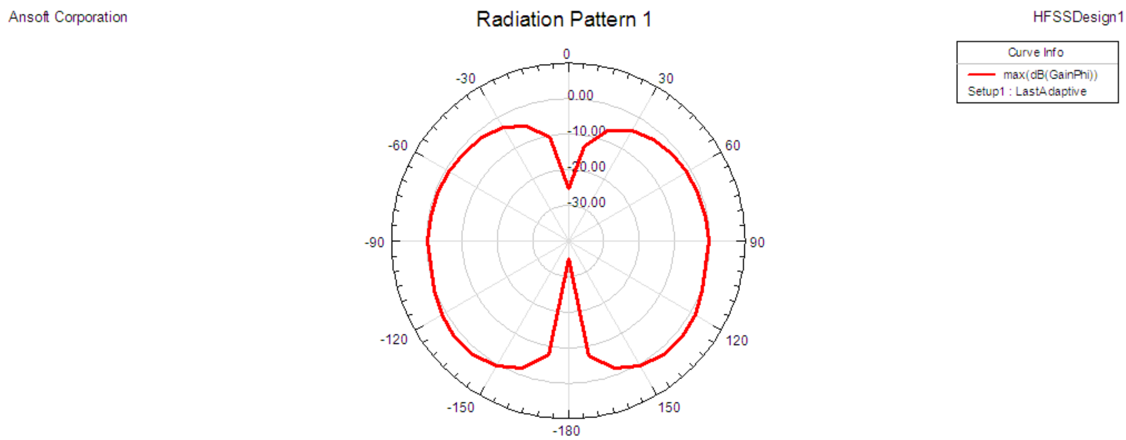

Fig 6. Radiation pattern of the proposed structure.

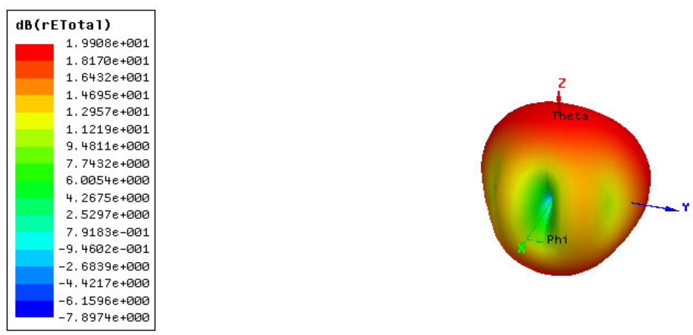

Fig 7. 3-D Radiation pattern of the Simulated structure.

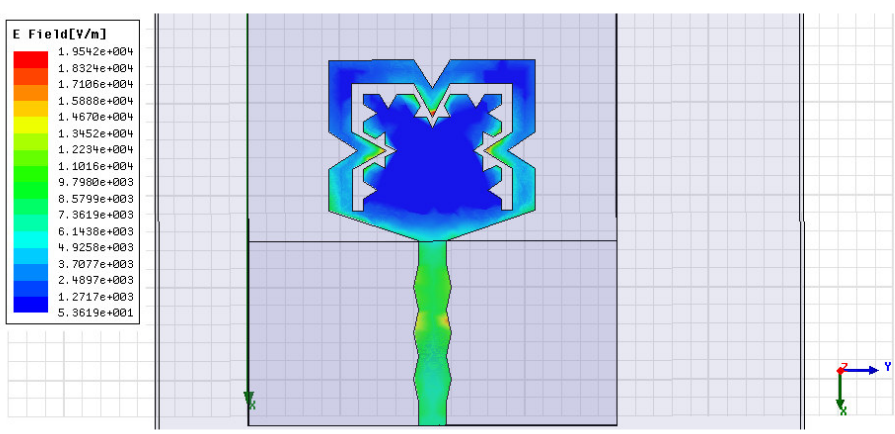

Fig 8. Electric field vector for complex E-Field of the Patch.

Conclusion:

A hybrid antenna with fractal shapes was represented in this paper. The proposed design is low in cost, easy to fabricate and integrate with microwave circuits, and multiband in operation. The electrical properties of the antenna are increased using the Koch fractal geometry without increasing its overall size.

The resonating frequencies are made to be practically applicable by using different dielectric materials. Roger5880 shows the multiband operation with increased bandwidth and applicable operating frequencies. The radiation pattern also shows the omnidirectional behaviour of the antenna.

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