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Performance Enhancement And Implementation Of Sierpinski Based Fractal Antenna For Wimax, Gps, Short Range Vehicular Communication

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Abstract: In present days number of vehicles is being increased. The traffic and road accidents have become more serious and social health issue. To overcome road transport issue, intelligent transport system is being developed. Microstrip fractal pentagonal antennas are the most suitable for the intelligent transport system. Because it has tri-band, low profile , light weight and low power handling capacity. This microstrip fractal antenna is designed to retrieve minimized patch size, enhanced gain, increased bandwidth, improved return loss and all the results of resonant frequencies by maintaining the aperture coupled feeding as constant. The multilayered structure with electromagnetic feeding technique helps the antenna to achieve Improved gain at all the three of its operating frequency in the desired directions.The performance parameters of fractal antennas are designed and simulated by using Ansoft HFSS 13.0 simulator.
Keywords Fractal antennas,Sierpinski,Tri-band,return loss,gain,ITS

I. INTRODUCTION

The Intelligent transport system is being enhanced to acquire reliability, low cost, high performance and low delay traffic safety applications. The intelligent traffic system uses vehicle safety equipment such as edge feature detector, side view cameras, solid state infra-red detectors and dynamic angling side view mirrors. But the cameras, edge feature detector and infra-red detectors have performance limitations under circumstances such as weather conditions,cost etc. Dynamic angling side view mirrors are mechanically controlled devices which could be damaged by everyday use.

These economical and technology problems are solved by using the micro strip patch antennas for radio frequency applications such as GSM, Vehicular to Vehicular communication and blind spot detection etc. In present days, the design of miniaturized micro strip fractal antennas provides multiple resonant frequencies for multiple applications. Many of the research papers have been proposed for new antenna designing technique based on fractal geometry.in addition; this paper provides the proper selection of fractal geometry, minimized antenna size, multi-band operation. Fractals are set of geometrical structures, which have two main properties such as Self similarity and Space filling property. Space filling property is used in the reduction of antenna size and Self similarity is used in the similar radiation characteristics in all resonant frequencies. The present paper proposes a different tri-band microstrip fractal patch antenna for intelligent transport system. It is a multi-layered structure that incorporates pentagonal sierpinski fractal geometry. The performance of the patch is analyzed and compared to a pentagonal patch without fractal configuration to assess antenna size reduction, overall gain, bandwidth in the modified design. In this patch antenna the centre of the non-radiating space is utilized efficiently by etching process.

The proposed fractal antenna can operate at trib and such as 1.3GHz forGSM,4.5GHz for vehicular to vehicular communication and 8GHz for blind spot detection.

II. ANTENNA DESIGN

A. Formulation of pentagonal patch dimension

The resonant frequency of a pentagonal microstrip patch antenna is derived from the resonant frequency equation of the circular microstrip patch antenna [8] as shown in Fig. 1. The resonant frequency of the hexagonal microstrip patch antenna is given by (1).

$$f_r = \frac{\chi_{mn} c}{5.7138 s \sqrt{\epsilon_{reff}}} \qquad \text{\_\_\_\_\_\_(1)}$$

Where

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$\chi mn = \chi 11$ (for $TM11$ mode) = 1.84118;
$\chi mn = \chi 21$ (for $TM21$ mode) = 3.05424;
and$\acute{\varepsilon}reff$is the effective dielectric constant of the substrate material.

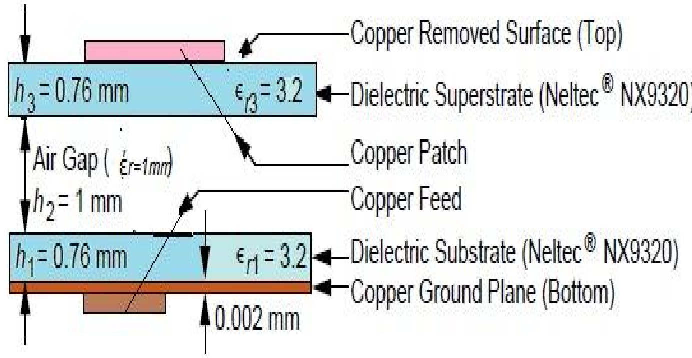

Fig.1. Multi-layered structure

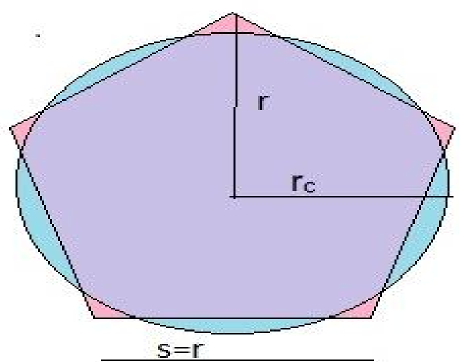

Fig.2. A circle and a pentagonal with equal areas.

B. Multi –Layered Structure and Substrate Materials

By using nylon spacer, 1 mm air gap is calculated between the upper and lower dielectric substrates. The proposed pentagonal patch is placed on top of the second substrate material. The height of the pentagonal microstrip patch antenna 1.76mm from the ground substrate .The copper feeding is given at the bottom of the first (bottom) substrate. To simulate the microstrip pentagonal sierpinski patch arlon3D material is used as a substrate material with dielectric constant $\acute{\varepsilon}r$=3.2 is selected to provide better efficiency and increased bandwidth. The antenna is fed by using aperture coupled feeding in order to increase the bandwidth and the gain.

C. Pentagonal Patch With Modified Sierpinski Fractal

Pentagonal patch antenna is designed to operate at three frequencies. Initially sierpinski pentagonal fractal patch antenna is designed to operate at 1.5GHZ frequency. Then the design continues for other two frequencies such as 4.5GHz and 8GHz.Using (1) side length of pentagonal patch is calculated to be 43.18mm.The average current path L is equal to the side length of the pentagonal patch antenna. Hence

L=s=43.18mm _________ (2)

D. Dimension Of Pentagonal Patch With Modified Sierpinski Fractal

The sierpinski fractal is introduced at the center of the patch so the patch size is minimized.Etching process is introduced in the patch at various angles such as 30^0,45^0, 90^0 ,120^0 ,180^0 ,270^0 ,$360^0$for further miniaturization. Fig (a) represents the general structure

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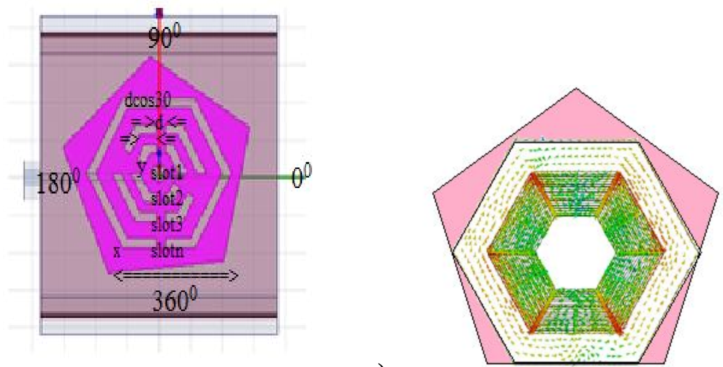
of sierpinski fractal antenna and it is essential to know the current distribution of proposed antenna. Fig (b) shows the current distribution paths of the pentagonal sierpinski fractal antenna. By calculating the current path length between its nulls, the resonant frequency of the patch is calculated.



a) b)

Figure 3. (a) General Structure of hexagonal patch with modified Sierpinski fractal structure . (b) current paths for evaluation of resonant frequency of the patch.

For the proposed structure the average current path L is observed from the surface of current distribution by the following equation

$L = X + 2(Y + nd + nd\ COS30^0)$____(3)

Where X and Y are general structure as portrayed in Fig 3(a). n is the no of slot rings etched from the center to the side of the pentagonal patch in a radial direction. By sierpinski fractal theory the inner most side length is equal to the $1/3^{rd}$ of outer most side length of the pentagonal .The current path is always constant for all slots rings so L=S is maintained in all slots.

Therefore,

S =_______(4)

From (4), the modified pentagonal sierpinski fractal patch length is smaller than the length of pentagonal patch without fractal. The analysis and parametric values have been found by Ansoft HFSS 3.1 software. Parametric values are different for various resonant frequencies that is L1=S1=58.30 mm, X1=24mm, n1=9 and d1=0.52 mm for 1.5GHz.These parametric values are enough to make the proposed antenna operate at 1.5 GHz. These parametric value shows the pentagonal patch is reduced by 75%. In the modified sierpinski fractal , the center of the pentagonal patch is utilized by the small hexagonal etching so non radiating place is reduced at the center .The small hexagonal Dimensions are L2=S2=11.56 mm, X2=5.25mm ,and d2=0.39 mm. These parameters are helpful for the antenna to operate at 8GHz. These 1.5 GHz and 8GHz are operated by its individual hexagonal and pentagonal patches contribution, but the third frequency band(4.5 GHz) of the patch is developed by combined electromagnetic effects of two patches . The current paths of the third frequency is not calculated by (3) and (4) .It is calculated by individual pentagonal patch current distribution path and the accuracy of tri- band is calculated by using (1) which are demonstrated in table.1

Resonant frequency (GHz)	*L calculated* (mm)	$L_{proposed}$(mm)	Percentage of error
1.5	43.18	48.30	11.86%
4.5	11.528	11.566	0.32%
8	9.4468	9.4472	0.42%

Table.1 Calculated and simulated L values

From the above tabulation can understand if the resonant frequency is increased, the accuracy is also increased. The finite dielectric of the substrate and ground plane area covers 75 mm X 75 mm and the length of the aperture couple feed line is F_L =37.12 and width of this strip line is F_N = 1.82 mm

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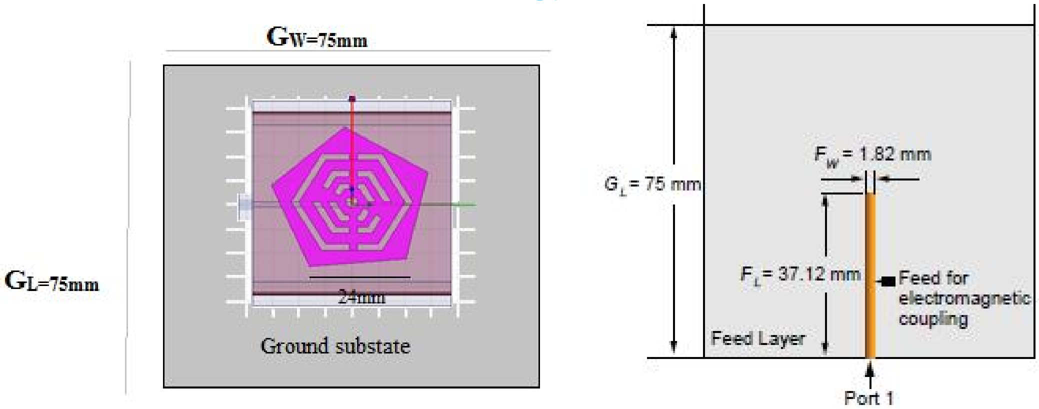

Figure 4. Layout of the antenna geometry.

III. SIMULATION RESULTS

The designed antenna is simulated by Ansoft HFSS DESIGNSTUDIO™ antenna design software. The proposed Tri band aperture coupled fractal antenna is operating at 1.3 GHz with return loss -19.181 and 4.5GHz with return loss -21.932, and 8 GHz with return loss -16.5. This is shows in fig.5

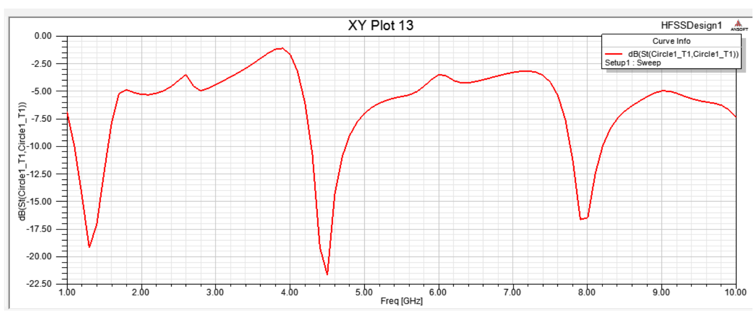

Figure.5. simulated results of return loss at various frequency

The proposed tri band aperture coupled fractal antenna (fourth iteration) is operating at 1.3 GHz with VSWR 1.2617 and 4.5GHz with VSWR 1.3615 and 8 GHz with VSWR 1.2115. This shows in fig.2.

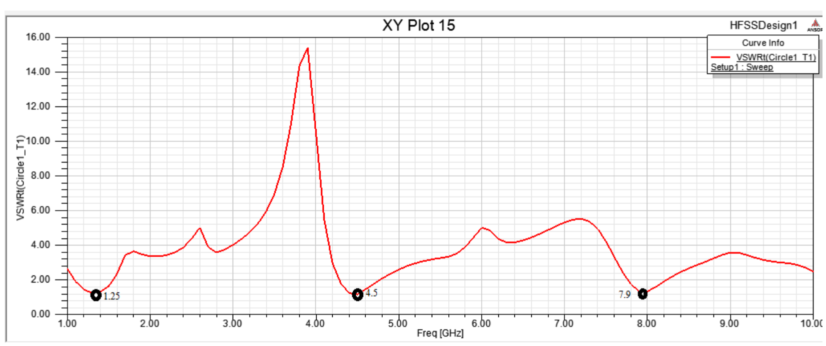

Fig.6. Simulated results of VSWR of proposed antenna

The radiation pattern with resonant frequencies 1.3 GHz, 4.5GHz and 8 GHz are represented in figure7. The proposed aperture coupled fractal antenna achieved gain of 1.661dB at resonance frequency 3.529 GHz and 5.167dB at resonance frequency 5.176GHz. The 3D pattern of directivity is shown in fig.4. The directivity is 5.054dBi at 3.529GHz and 5.492dBi at 5.176GHz. The 3D pattern of gain is shown in fig.4. A maximum radiation in patch antenna size of 75% is achieved when using fourth order iteration of MIB fractal antenna.

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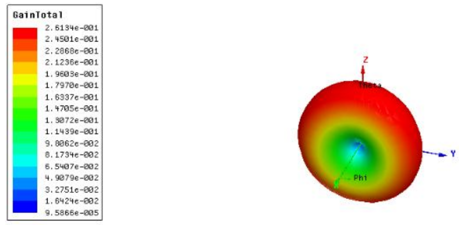
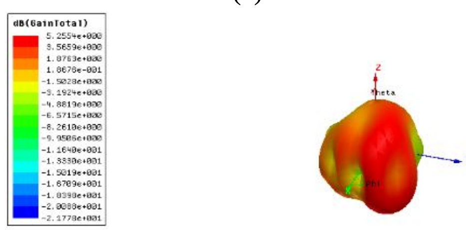


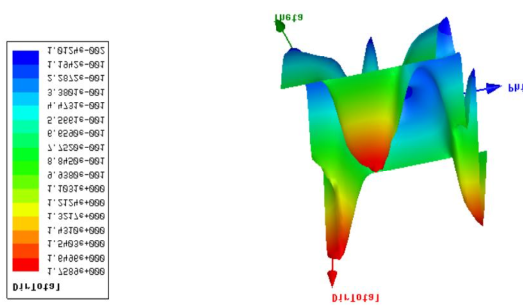
a)

(b)

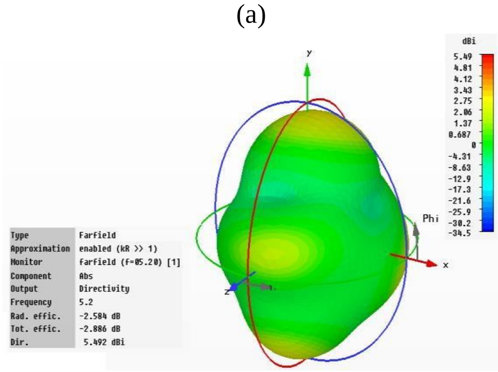


(c)

Fig.7. 3D view of gain at (a) 1.3 GHz ,(b) 4.5 and (c) 8 GHz



(a)



b)

Fig.8 a)3D view of directivity at 1.3GHz and b)4.5GHz

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IV. CONCLUSION

The existing Tri band frequency aperture coupled fractal is designed and Ansoft HFSS DESIGNSTUDIO™ Microwave Studio. Its return loss, radiation pattern is obtained. The proposed third order aperture coupled fractal is also designed and synthesized using Ansoft HFSS DESIGNSTUDIO™ Microwave Studio. The existing antenna achieved bandwidth of 79.67MHz at 4.5GHz and 105.16MHz at 8GHz resonant frequency. Using proposed fourth iteration aperture coupled fractal antenna is achieved .The bandwidth of 4.5GHz is 74.298MHz and 115.82MHz at 8GHz resonance frequency. So, that can be used various applications mainly Wi-MAX and GPS and short Range Vehicular communication. A maximum reduction in patch antenna size of 78.16% is achieved when using Sierpinski based fractal antenna. The proposed Hexagonal etch aperture coupled fractal antenna achieved bandwidth of 70MHz at 4.5 GHz and 108.14MHz at 8 GHz resonant frequency. A maximum reduction in patch antenna size of 75% is achieved when using Sierpinski based fractal antenna.

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