Design of Fractal Antenna for GSM Phone Applications

[1] Mahesh V. Tank , [2] M. D. Amipara
[1.] Electronics And Communication Engineering, GTU ,Noble Group Of Institution JunagadhGujarat , India.
[2.] Balaji Institute of Engineering and Technology Junagdh ,Gujarat ,India

***Abstract*— A novel fractal antenna on the planner design is presented in this Paper. Designing a Fractal Planar Antenna is explained and the 2nd iteration of Sierpinski Carpet is chosen as an antenna for mobile phones. This proposed Antenna is designed at 900 MHz and it is optimized to receive GSM (Global System for Mobile Communication) with high value of return loss and has an almost Omni-directional radiation pattern. On the Basis of Simulation result performance met all the criteria for a mobile phone application.**

***Keywords*— MicrostripLine, Fractal antenna, Planar Antenna, GSM, etc.**

I. INTRODUCTION

Fractal antenna has been proved to be an effective technique to design small and multiband antennas. Fractal antenna geometry represents self-similarity and repeats itself in different dimensions filling the space effectively [1-2]. The advantages with the fractals are of multiple electric dimensions, self-loaded to 50 ohm, auxiliary reactance and capacitance not needed, mutual coupling between array elements can be reduced substantially and many more. Several geometries are available like Helix, Koch curve, Hilbert curve and Sierpinski carpet etc. the reason why there are no more novel fractal antennas emerged in recent years is mostly that fractal geometry is complicate and difficult to be constructed through its configuration rule is only virtually simple iteration[3-5].There is an important relation between the antenna dimensions and the wavelength. The relation states that if antenna size is less than λ/4 then antenna is not efficient because radiation resistance, gain and bandwidth are reduced and therefore antenna size is increased. Fractal geometry is very good solution for this problem. These structures are recognized by their self-similarity property and fractional dimension [6-8]. In the recent years, the geometrical properties of self-similar and space filling nature has motivated antenna design engineers to adopt this geometry a viable alternative to meet the target of multiband operation. Fractal dimensions, self-similar and scaling properties, characterize these structures. The structures that are studied as antenna are not the once that we obtained after infinite iteration but those after finite iterations asdesired by the designer. The space filling property lead to curves those are electrically very long but fit into a compact physical space. This property can lead to the miniaturization of antennas [6-8].

II. ANTENNA GEOMETRY

In the design of this type of antennas, the width 'W' and Length 'L' of the patch of the antenna plays a crucial role in determining the resonant frequency of the system. For Microstrip antennas, the width (W) and length (L) of the radiating patch and the effective permittivity of the Microstrip structure (εr)which support the operation at the required resonant frequency or (the free-space wavelength (λ_0)) can be designed as follows, using the formulas given as [1-3].

$$W = \frac{c}{2f_r}\sqrt{2}/\sqrt{\varepsilon_{r+1}} \qquad (1)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\sqrt{1 + 12\frac{h}{W}} \qquad (2)$$

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} \qquad (3)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)}{(\varepsilon_{reff}-0.258)}\frac{\left(\frac{W}{h}+0.264\right)}{\left(\frac{W}{h}+0.8\right)} \qquad (4)$$

$$L_{eff} = L + 2\Delta L \qquad (5)$$

where
εe = Effective dielectric constant
εr = Dielectric constant of
substrate h = Height of dielectric
substrate W = Width of the patch

In the design of this type of antennas, the width 'W' and Length 'L' plays a crucial role in determining the resonant frequency of the system. The starting values of these parameters are calculated by using the equations given in [1] for the substrate height (h), dielectric constant (εr) and for the lower frequency. The designed values of the antenna are optimized with HFSS tool. The optimization was performed for the best impedance bandwidth. The proposed antenna has following dimensions.

Table 1: Antenna Dimensions

Simulation Design Parameter	Values
Dielectric constant of the substrate(FR4)	4.4
Thickness of the substrate (h)	0.24 cm
Height of Patch and Ground	0.0035cm
Width of the patch (W)	13.65 cm
Length of the patch (L)	10.7 cm
Design frequency (f)	900 MHz

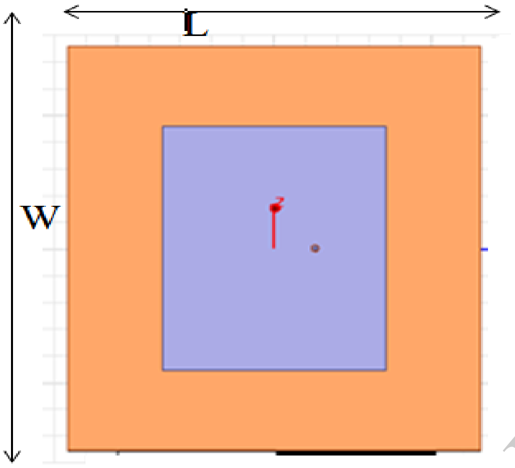


Fig. 1.Geometry and configuration of planer antenna.

Fractal technology allowed us to design miniature antennas and integrate multiple band into a single device. Fractals are objects, which display self-similarity on all scales [5-9]. Two basic characteristics of a fractal are self-similarity and the fractal dimension. An object is said to be self-similar if it look roughly the same on any scale. The estimated length, L, of an object equals the length of the ruler, r, multiplied by a number, N, of such rules needed to cover the measured object. If we reduce an object in Euclidian dimension D and reduce its linear size 1/r in each spatial direction its measure would increase to $N = r^D$. Solving for D, the equation become:

$$D = \frac{\log N}{\log r} \qquad (6)$$

This is known as the Hausdorff dimension [2].

Fractal antennas are antennas that have the shaped of fractal structures. The fractal antennas consist of geometrical shapes that are repeated. For the fractal design this procedure has to be followed [3]

N_n = number of black boxes,

L_n= ratio for the length,

A_n = ratio for the fractional area after the nth iteration and

d_n = capacity dimension.

$$N_n = 8^n \qquad (7)$$

$$L_N = \left(\frac{1}{3}\right)^n \qquad (8)$$

$$A_N = \left(\frac{8}{9}\right)^n \qquad (9)$$

$$dn = -\lim_{n\to\infty}\left(\frac{\ln Nn}{\ln Ln}\right) = 1.89 \qquad (10)$$

For getting the perfect frequency band of the antenna we design the patch of the antenna. The dimension of cuts as shown in fig. these slots improves the return loss and bandwidth of proposed Antenna. On basis of fractal geometry proposed structure defined as bellowed.

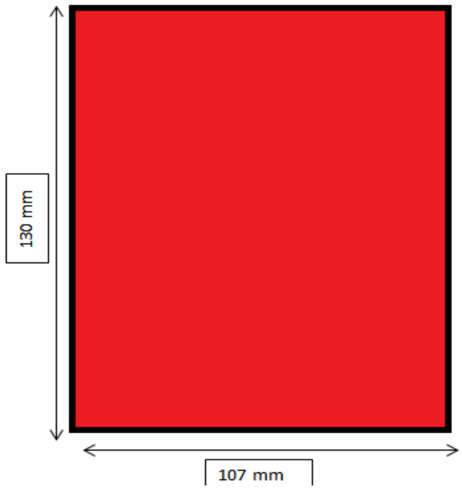


Fig.2 Geometry of patch antenna.

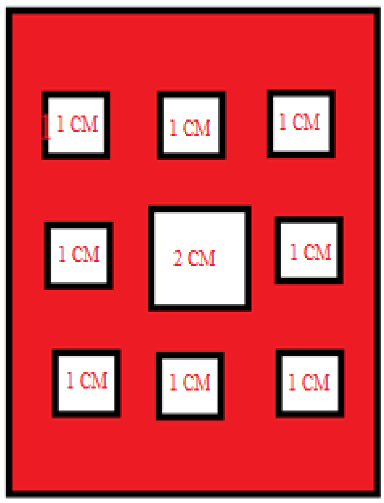


Fig.3 Geometry of 2nd Iteration Fractal antenna.

III. SIMULATION RESULTS

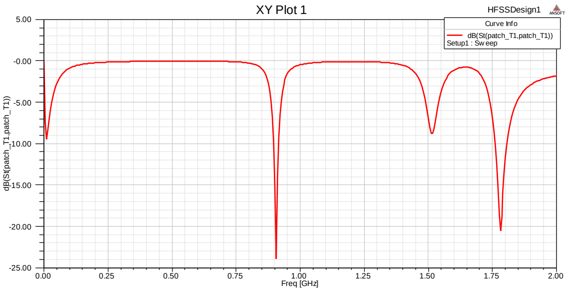


Fig. 4 Return loss(S11) of fractal antenna.

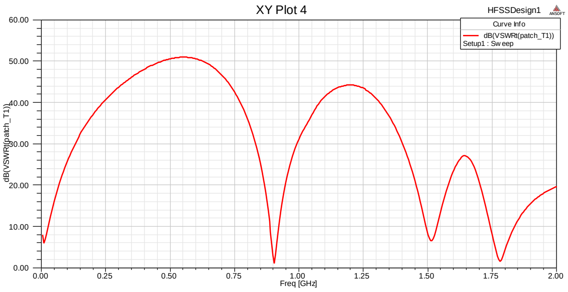
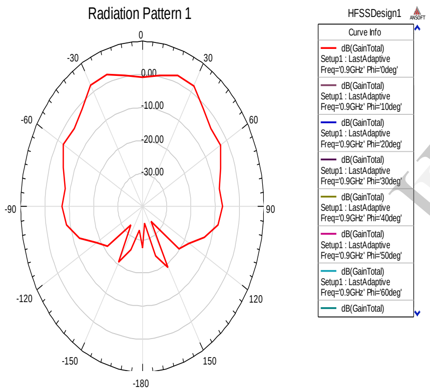
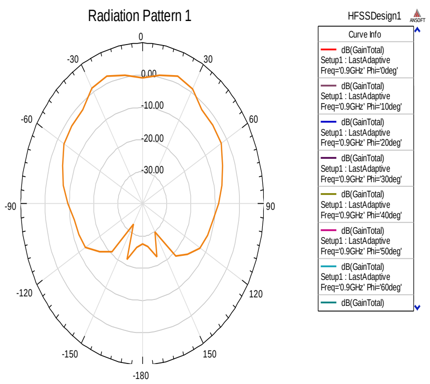


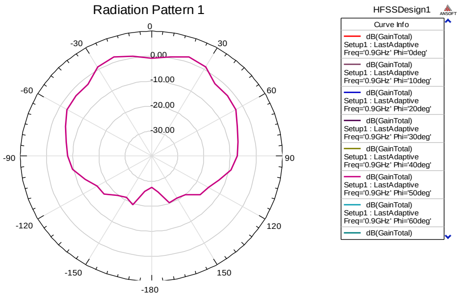
Fig. 5 VSWR of fractal antenna



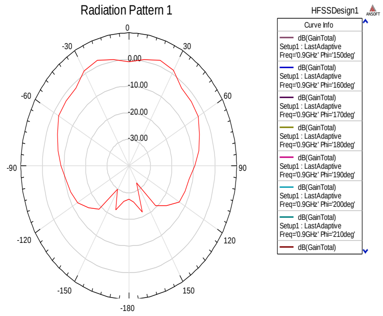
(phi=0)



(phi=90)
Gain for proposed fractal at 900 MHz

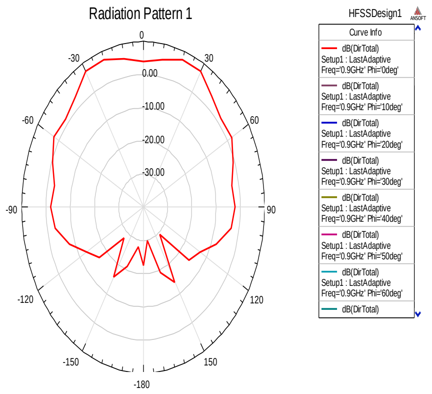


(phi=0)

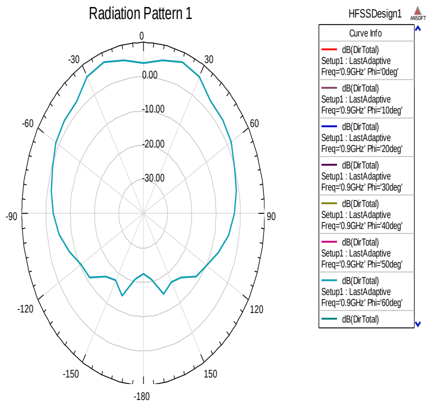


(phi=90)

Gain for proposed fractal at 1800 MHz
Fig.6 Gain for proposed fractal Antenna



Directivity at 900 MHz



Directivity at 1800 MHz
Fig. 7Directivity of fractal antenna.

Table 2: Antenna Results

f_r	Gain (db)			Directivity (dbi)		
	0 iteration	1st iteration	2nd iteration	0 iteration	1st iteration	2nd iteration
900 MHz	3.21	2.01	2.79	6.96	5.02	7.45
1.8 GHz	-	2.12	2.67	-	5.34	7.67

IV. RESULT DISCUSSION

In order to assess the effectiveness and reliability of the design, analysis is carried out and some representative results are reported in the following to give an overview of the performance. All the simulated data have been obtained by means of an electromagnetic simulator on the Finite Element Method (FEM). By considering the electrical performance of the antenna, simulation results of return loss parameter |S11| are shown in fig 4, which consisting of return loss curve for all the iterations with respect to the frequency.S11 & VSWR results show the proposed antenna can cover 900 MHz and 1800 MHz with respectively Return loss is 23db and 17db with respective VSWR is 1.4 and 1.8 as shown in fig 4 and fig 5 .It cover band of 100 MHz at resonant of 900 MHz and 80 MHz at 1800 MHz Based on the simulated and analysis of the Microstrip antenna, we have discussed the size and design parameters. Then we simulated the antennas that can run at 900 MHz with average gain and directivity are respectively shown as per Table 2 data, which suits the real cellular applications. For the higher band of operation. An optimization between size reduction and bandwidth enhancement is maintained in this work. The impedance matching requirements at these frequencies are fully satisfied as indicated by the simulated values of |S11|, the return loss and the resonating frequencies are tabulated for all iterations are presented in the table 1. The bandwidth of the antenna is calculated at -6dB return loss by taking its limits at the upper frequency and lower frequency. The fractal antennas are fed with coaxial probe with perfect matching by placing at proper feed location. EM wave propagates along the fractal lateral sides to the base sideattenuating on and on. Low frequency has long wavelength and can travel to the furthermost while high frequency has a shorter wavelength and can only travel to the proximal ends away from the base side vertices. Fig 6and Fig.7shows the antenna radiation pattern at phi=00and 900for iteration 2, which is resonating at dual band.

V. CONCLUSION

Simulation results show the proposed antenna can cover 900 MHz and 1800 MHz with respectively Return loss is 23db and 17db with respective VSWR is 1.4 and 1.8 as shown in fig 4 and fig 5 .It cover band of 100 MHz at resonant of 900 MHz and 80 MHz at 1800 MHz Based on the simulated analysis shows that the proposed antenna can be work on GSM band applications. The gain of proposed design is also sufficient for GSM cellular dual band applications.

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