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Design and Simulation of Fractal Antenna

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Abstract: Now-a-days in modern wireless telecommunication systems, antennas with smaller size, greater efficiency, and wider bandwidths are in great demand. To fulfil these requirements fractal concept in antennas is very popular which provides compactness and can generate multiple frequencies and also enhances its bandwidth. So this paper presents design and simulation of Square shaped fractal antenna using HFSS 15.0 software. This Square shaped fractal antenna is designed for 3 GHz resonant frequency using FR-4 epoxy as substrate. Also the simulated results are presented in this paper.
Keywords: Fractal Antenna, High Frequency Structure Simulator (HFSS), FR-4 Epoxy Substrate, Wireless Communication

I. INTRODUCTION

In wireless communication system antenna plays important role of capturing the band of interest for the specific application & technology. antenna are a vital & basic segment of all close to home electronic gadgets, microwave & satellite correspondence frameworks, radar frameworks & military observation & surveillance stages. In a significant number of these frameworks, there is a prerequisite to play out a huge number of capacities over a few recurrence groups & working data transfer capacities. In most cases, these necessities can't be served by a solitary antenna but instead require the utilization of various antennas of changing structure variables & geometries which will in general increment manufacture costs, framework weight, framework volume, & assets required for support.

Considering the present situation of development of antennas in the wireless communication field, there is great demand for small size multiband with multiple function & cost effective antenna. Therefore a fractal antenna is now a day"s considered as one of the important concept in antenna development field for remote correspondence handsets. The main point of utilizing a fractal antenna that it has to work in multiband where the all out antenna size can be reused & in this way the general volume of the antenna can be decreased. Additionally, the fate of phones & other individual cell phones require little size multiband & brilliant antenna with reconfigurable concept.

This paper includes design & simulation of square shaped microstrip fractal antenna. Fractal concept in antenna is one of the latest terminologies in investigate for antenna structure, their key advantage being their capability to upgrade electrical length of antenna without making changes in antenna size & better performance. The antenna structure comprises of a transmitting component in the structure of fractal patch of square shape encouraged by a feed length on its facing side.

II. FRACTAL ANTENNA DESIGN

In this design the FR4 epoxy substrate is used as a substrate material with dielectric constant 4.4, thickness 1.6mm and the resonant frequency taken as 3 GHz. There are many parameters has been taken into consideration while designing patch antennas such as resonant frequencies, substrate thickness, length of the patch, width of patch etc. These dimensions are calculated by using the rectangular patch design equations (1) to (7) as shown below [1].

The Width of Patch element (W) is calculated using

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (01)$$

The Effective Dielectric Constant is calculated using

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}} \qquad (02)$$

The Effective Length is calculated using

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} \qquad (03)$$

The Length Extension is calculated using

$$\frac{\Delta L}{h} = 0.412\,\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)} \qquad (04)$$

The actual length (L) of the patch is calculated using

$L = L_{eff} - 2\Delta L$ (05)

Where C = Velocity of light in free space

h = Substrate height

ε_r = Relative Permittivity of Substrate

Calculation of Substrate (or Ground) Length and Width

$$L_g = L + 6h \qquad (06)$$

$$W_g = W + 6h \qquad (07)$$

Where $h = \frac{0.0606\lambda}{\sqrt{\varepsilon_r}}$

Table1: Design Parameters of Antenna

Sr. No.	Parameter	Value
1	Operating Frequency	3 GHz
2	Dielectric Constant of Substrate	4.4
3	Length of the ground and substrate	47.75 mm
4	Width of the ground and substrate	47.75 mm
5	Length of the Patch	30.42 mm
6	Width of the Patch	30.42 mm
7	Height of the Substrate	1.6 mm

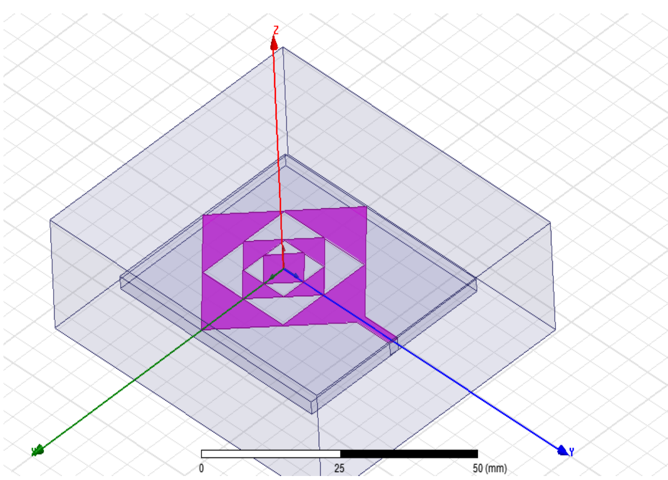

Fig.1: Square shaped Fractal Antenna in HFSS

III.SIMULATION RESULTS

Ansoft HFSS is a high performance full wave electromagnetic (EM) field simulator. It integrates simulator, visualization, solid modeling and Automation in an easy-to-learn environment where the solution of the 3D EM problem is quickly and accurately obtained [3].After the completion of the design part of proposed antenna, simulated results such as Reflection Coefficient, VSWR, Radiation and current distribution pattern and Gain obtained and that are as follows-

Figure 2 shows reflection coefficient at frequency 4.3 GHz, & it is -22.58 dB. The acceptable return loss value is -6 dB. Reflection coefficient is a proportion of adequacy of intensity conveyed to a heap, for example, a antenna. In the event that the power occurrence on the antenna is Pin & the reflected power from the radio wire to the source is Pref. the level of confuse between the reflected & occurrence control is given with (3.1). It is a logarithmic proportion estimated in dB that looks at the power reflected by the antenna to the power that is sustained into the radio wire from the transmission line.

$$Reflection\ Coefficient = -10log10(\frac{Pin}{Pref})$$

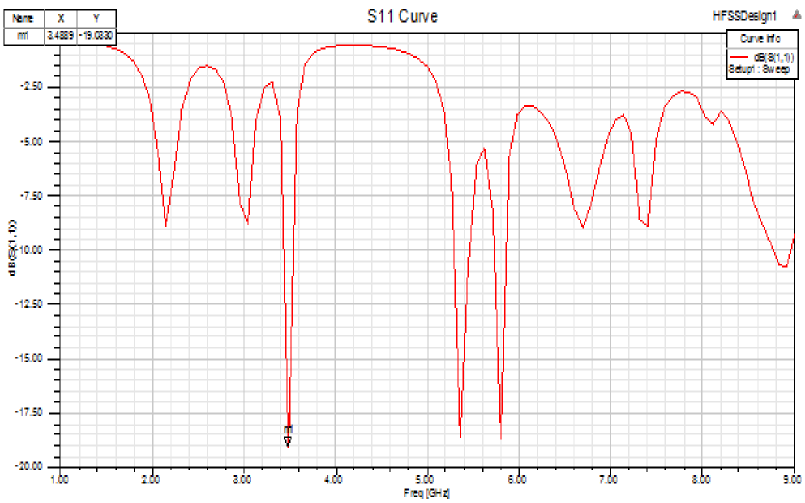

Fig. 2: Reflection Coefficient

The VSWR represents Voltage Standing Wave Ratio, & it is likewise alluded as standing wave proportion (SWR). VSWR is a component of reflection coefficient which portrays control reflected from the antenna. The VSWR plot of square formed fractal radio wire is appeared in Figure 3, which is 1.94 for frequency 3.48 GHz. Ideally, VSWR must lie in the range of 1-2 near the operating frequency value.

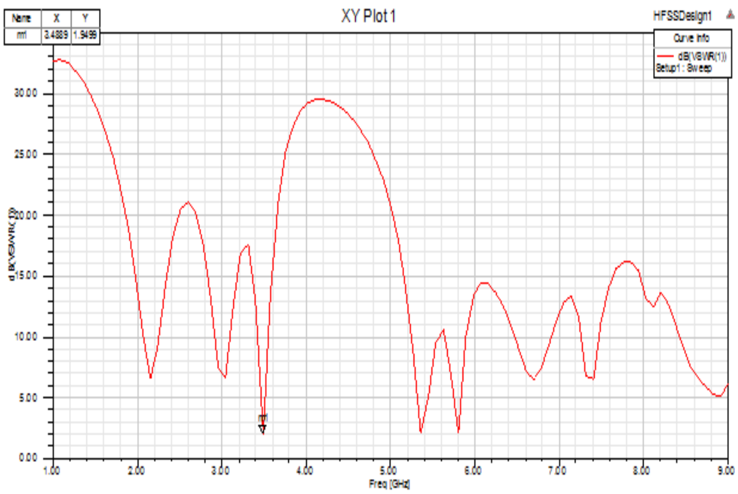

Fig. 3: VSWR

The Gain of the antenna basically shows the efficiently antenna works. Gain of antenna is that parameter that describes the capability of antenna to direct energy through a given direction to give a better picture of the radiation performance. Gain is usually expressed in dB which refers in the direction of the maximum radiation. In proposed antenna design, the maximum achievable gain is 5 dB. Figure 4 shows the simulated result of the gain of the proposed antenna.

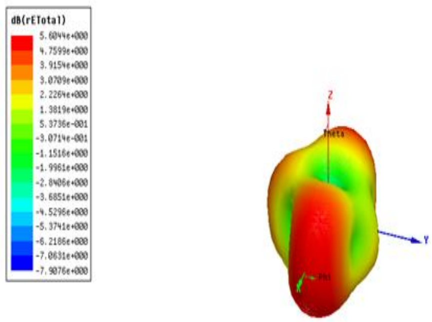

Fig. 4: Antenna Gain

The Radiation pattern of Microstrip Patch Antenna describes the power radiated or received by the antenna. It is the function of angular position and radial distribution from the antenna. The radiation pattern of the proposed Microstrip patch antenna is shown in Figure 5.

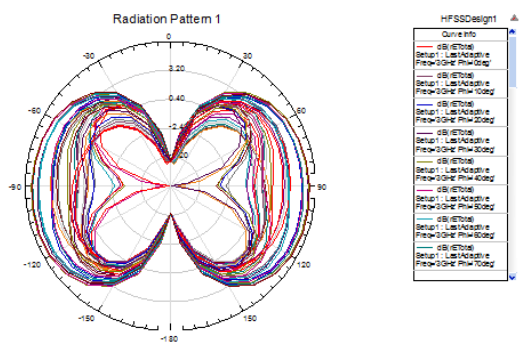

Fig. 4: Antenna Radiation Pattern

For a straightly captivated antenna, E-plane is the plane containing the electric field vector & the bearing of most extreme radiation. The electric field or "E" plane decides the polarization or direction of the radio wave. H-plane is the plane containing the attractive field vector & the bearing of most extreme radiation. The polarizing field or "H" plane lies at a correct point to the "E" plane. E-plane & H-plane ought to be 90 degrees separated. The Simulated results for E-plane and H-plane is shown in figure 5.

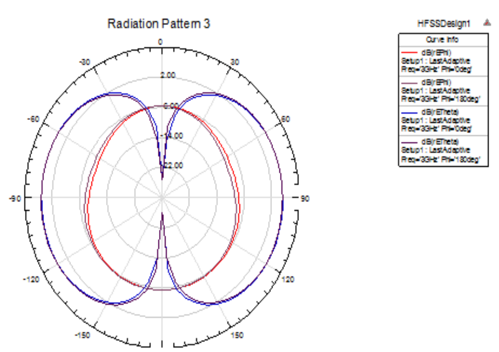

Fig. 5: E-plane & H-plane measurement of square shape fractal antenna

Figure 6 shows surface current circulation at the thunderous recurrence for the antenna. The non- radiating edge has an effective current along it which is smaller than the physical length. The effective current length is responsible for the resonant frequency. A smaller effective current length pushes the resonant frequency upward.

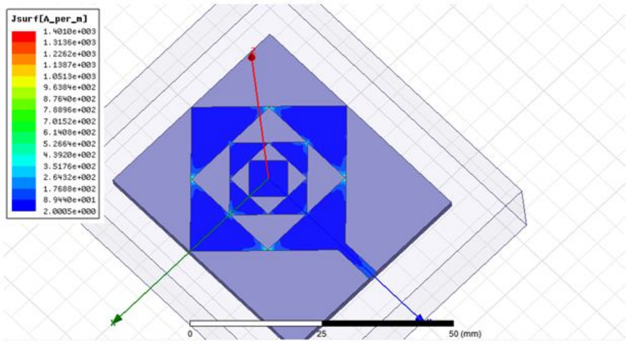

Fig. 6 Surface Current Distribution

IV. CONCLUSIONS

A Square Shaped Fractal Antenna with Square Shaped fractal patch and FR-4 epoxy as substrate have been successfully designed according to its design specifications, simulated and analyzed using HFSS software. The performance of the proposed antenna is described in terms of reflection coefficient, VSWR, gain and radiation pattern which achieves the required or desired results.

V. ACKNOWLEDGMENT

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