Design of Star Shaped Fractal Antenna for Wireless Applications

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Abstract- This paper proposes a star shaped fractal antenna with microstrip feed line. Several efforts have been made by various investigators around the globe to amalgamate benefits of fractal structures with electromagnetic concepts and applications. Second iterative star shaped fractal geometry of the radiator, modified feed line and notch loaded semi-elliptical ground plane are used to achieve an impedance bandwidth of 2.36-2.77 GHz. Performance analysis of the antenna is done with its characteristics such as S-parameter, VSWR, efficiency and radiation pattern. The overall dimension of antenna is 40×38×1.6 mm3. Wireless application demands miniaturization in system as well as antenna size with better performance, hence attempts have been made to reduce the size and improve the gain, efficiency and bandwidth of the proposed antenna. The proposed antenna is useful for Wi-Fi and Wi-Max application with frequency of 2.4 GHz.

1. INTRODUCTION

In the last few years, wireless technology has witnessed tremendous developments and increase in the demands for high data rates over a wide range of frequencies i.e. short and long range transmission. To incorporate this technology in wireless communication devices, microstrip patch antenna (MPA) is widely preferred because of their very small size and compactness. These antennas can be easily fitted into radars, satellites, aircrafts and handheld wireless devices such as cellular, phones, pagers, etc. Therefore, many researches and developments are carried throughout the world for more compactness and less expensive. The patch may take up any configuration such as square, rectangle, circular, elliptical etc. but out of these rectangular and circular shapes are most used. Some antenna structures are designed by using monopole structures, fractal geometries, defected ground planes etc. Among these methods, fractal structures are proven to be good candidates as they enhance the impedance bandwidth without increasing the antenna dimensions [1].

A star shaped fractal antenna is designed and analyzed. The bandwidth is enhanced by using two iterations of the fractal geometry, modified feed line and notch loading of the partial semi-elliptical ground plane. It can support several pre-fixed communication standards like IEEE 802.11a band. It is designed and analyzed by using CST simulator. The simulated and experimental results are also discussed [2].

The important constraint in antenna design is the selection of substrate material. This is based on the availability, requirement, feasibility and intended applications. In view of compactness and weight, the parameters such as dielectric permittivity and thickness are considered important along with material selection. Additionally, the selection involves the identification of substrate material usage with single side or double side metallic printing. This type of feed planned for the design. If it is a single side printed board then CPW and Proximity feeding are the available methods. If a double-side printed substrate is preferred, then microstrip proximity or coaxial feeding method can be the possible choices. The radiating part (patch) of the antenna can be etched on the top side and the ground can be taken to the bottom side of the substrate chosen. The radiating patch is usually a conducting material whereas substrate is a non-conducting material whose dielectric permitivity can be in the range of $2.2<\varepsilon r<12$[2-5].

2. ANTENNA DESIGN

The final geometry of the antenna with optimized dimensions is shown in Figure 1. It is etched on 1.6 mm thickFR-4 lossy ($\varepsilon r=4.3$, tan $\delta=.025$) substrate with dimensions40 x 38 x 1.6mm^3. The geometry consist of ring with outer radius 11.54 mm and inner radius 10.54mm .Equilateral triangle with side 18.78 mm is inserted inside the ring, which is being fractal and forming stars of side 6.26mm each. Another ring is inserted at the center of geometry having outer radius 3.75mm and inner radious 2.75 mm. The antenna feed with microstrips feed line having dimension 19.46 mm x 3.6mm. The upper portion of microstrip feed line is tapered towards center for smooth transition between the modes. The conventional rectangular ground plane is replaced by semi-elliptical ground plane which improves return loss, gain and bandwidth. It is further loaded with a rectangular notch at the feeding location to improve the impedance matching. All the conductors and ground planes are assumed to be perfect during the simulation. The intermediate design steps are presented in Figure 2.

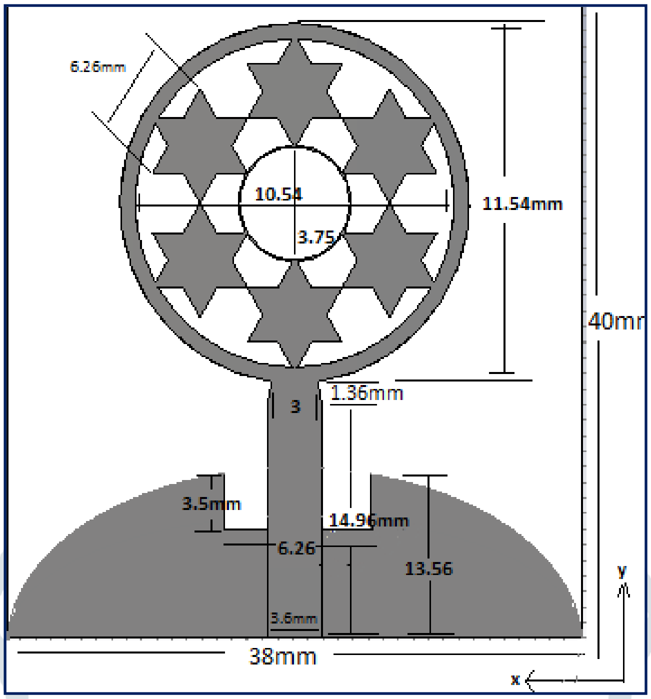


Figure 1: Geometry of the designed antenna

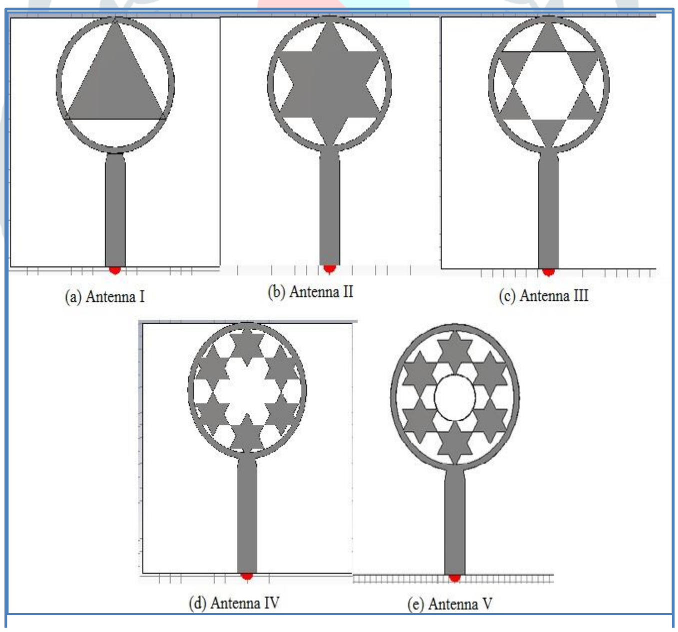


Figure 2: Intermediate steps of designing antenna structure

3. RESULTS AND DISCUSSIONS

We have designed and simulated star shaped fractal anteena in which we have focused on fractral shape since fractal means the self similar design. As fractal means dividing the straight line into three parts, so the fractal antenna gives us more radiation through edges of antenna. The figure 3 shows graph of Reflection coefficient. The antenna covers the band from 2.36 GHz– 2.77GHz with resonant frequency at 2.566 GHz. the effect of notch in the ground plane is examine. The reurn loss is decreased with increased in depth of nothch. At depth of 3.5 mm of notch we got optimized results.

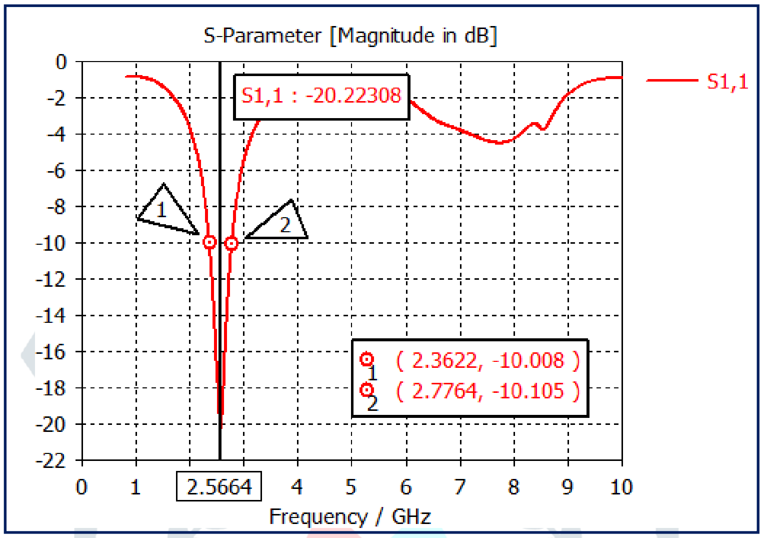


Figure 3: Reflection coefficient of fractal antenna

The voltage standing wave ratio is another important factor of antenna which indicates relation between power accepted and power delivered by antenna. The value of VSWR should be in between 1 to 2 for better performance of antenna. Here we got the VSWR of antenna 1.21 at resonance.

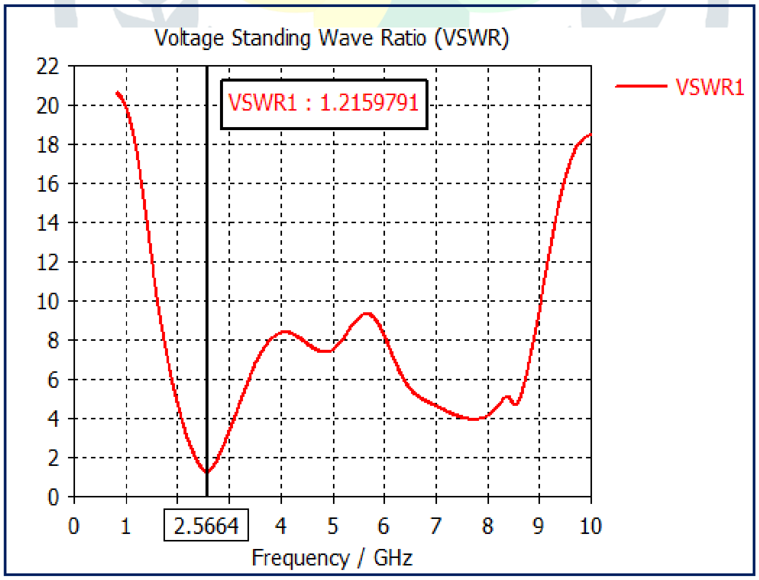


Figure 4: VSWR of fractal antenna

The impedance plot of fractal antenna is shown in figure 5. For maximum transfer of power the impedance of antenna should be match with impedance of transmission line. The value of impedance of this antenna is found 50.92 Ω which very close to standard value.

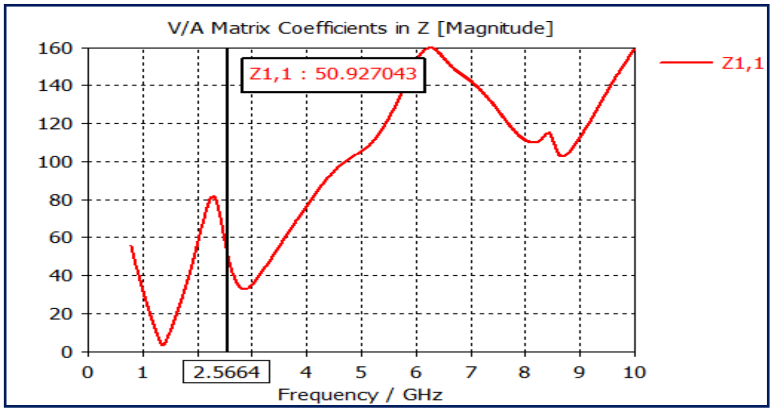
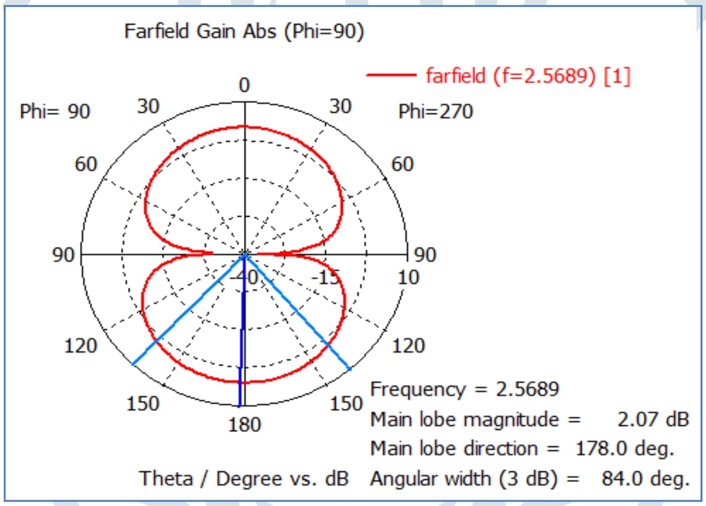
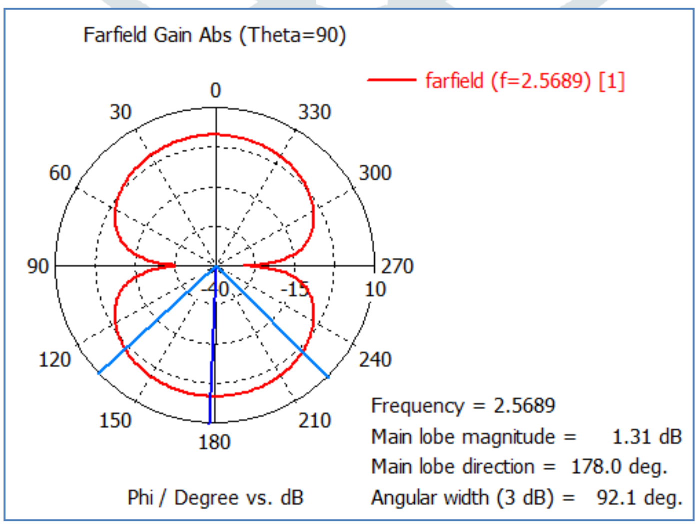


Figure 5: Impedance of fractal antenna

The radiation pattern is very important parameter which is indicated far field performance of Antenna. The 2D and 3D radiation pattern of antenna is plotted in figure 6 and 7 respectively. The gain of antenna is found 2.07 dB which is sufficient for Wi- Fi application.The beam width of antenna is slightly varying in horizontal and vertical plane.the main lobe strength is varies from 1.31 dB to 2.07 dB.



a. Gain with constant Phi



b. Gain with constant Theta

Figure 6: 2 D radiation Pattern of fractal antenna

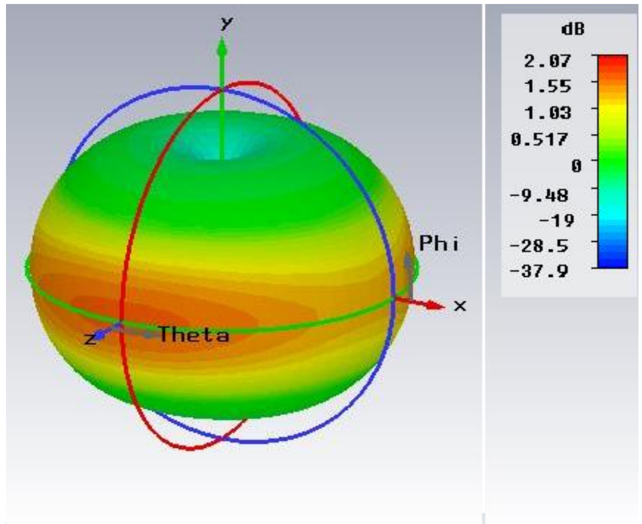


Figure 7: 3D radiation pattern of fractal antenna

4. CONCLUSION

A star shaped fractal antenna is designed and simulated. It has been observed that this antenna works in the band of 2.36 to 2.77 GHz. The impedance bandwidth of this antenna structure covers the Wi-Fi, and Wi-Max bands which are used for communication purpose.The gain of antenna is found to be 2.07 dB. The Antenna efficiency is above 90 % during the operating range which is very good for communication. The impedance of antenna is very close to 50 Ω.

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