International Journal of Microwave Engineering and Technology
Vol. 1: Issue 2
www.journalspub.com

Design and Analysis of Iterated Star Shaped Star Slotted Fractal Antenna

M. Dhakad*, P. K. Singhal
Department of Electronics, Madhav Institute of Technology and Science, Gwalior, Madhya Pradesh, India

Abstract
In this paper, A Novel star shaped iterated fractal antenna with circular slot in midway is proposed. Proposed antenna is very small in size and ground of antenna also defected by cutting approximately half PEC material. In this proposed antenna number of iterations has been applied. Proposed fractal antenna has high gain and bandwidth. This proposed Antenna is simulated by Computer Simulation Technology – Microwave Studio (CST-MWS) and different simulated results are analyzed. The self-similarity property of the fractal antenna is utilized for size reduction and multiband operation. Its radiation characteristics such as return loss, VSWR, gain, directivity, polar plot, etc. are analyzed and compared. CST is simulation software, with the help of this software reflection coefficient and some other parameters can be determined at various frequency ranges by varying frequency. For this proposed antenna designing CST software version 2010 is used.

Keyword: *fractal antenna, multi-band, CST software, return loss, patch antenna, defected ground structure*

****Corresponding Author***
E-mail: manojdhakad20@gmail.com

INTRODUCTION

Fractal term was coined in 1975 by the French mathematician, Benoit B. Mandelbrot. Fractal's products deliver unprecedented frequency coverage, versatility, and performance in form factors that area fraction of the size of traditional antennas. Modern wireless communication system require antenna with smaller dimensions and wider bandwidth.[1] A fractal can be described as a rough or fragmented geometric shape that can be separated into parts which are an approximation to the whole geometry but in a reduced size. Fractals are known as infinitely complex because of its similarity at all levels of magnification.[2] The fractal geometries repeat their geometries by a particular scale in successive iterations. Consequently, they will possess a long length in a limited confined volume. Accordingly, several fractal geometries, such as the Koch, Minkowski, Hilbert and tree fractals, have been applied to dipole and loop antennas.[3] Number of fractal antenna geometries have been suggested for wireless applications in the recent years.[4,5] Fractal antennas have stimulated significant research interest lately due to their advantages of multiband operation. The multiband behavior of fractal antennas is due to their self-similarity structure, which means that some of their parts have the same shape as the whole object but at a different scale.[6]

ANTENNA DESIGN SPECIFICATIONS

The geometry structural of the proposed fractal antenna is shown in the Figure 1. This proposed fractal antenna is designed and printed on FR4 (lossy) substrate with size of $40 \times 60 \times 1.6\ mm^3$, including substrate thickness say $h = 1.6$ mm and dielectric constant $\varepsilon_r = 4.4$ with 0.025 loss tangent. This structure designed by Computer Simulation Technology (CST) microwave studio simulation software. Defected ground plane structure is shown in Figure 2. The effective reflection coefficient and characteristics impedances were calculated with the help of Equation 1 and 2.

$$\varepsilon_{\mathrm{eff}} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r+1}{2}\left[\frac{1}{\sqrt{1+12\frac{h}{w}}}\right] \quad \text{Eq. (1)}$$

$$z_0 = \frac{120\,\pi}{\sqrt{\varepsilon_{\mathrm{eff}}}\left[\frac{w}{h}+1.393+0.667\ln\left(\frac{w}{h}+1.444\right)\right]} \quad \text{Eq. (2)}$$

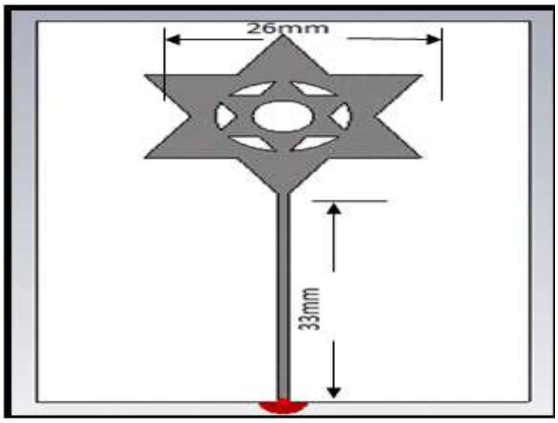

Fig. 1: *Front View Structure of Proposed Fractal Antenna.*

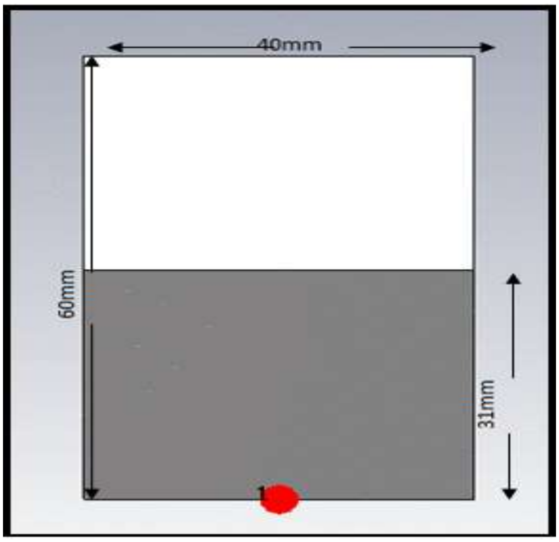

Fig. 2: *Back View Structure of Proposed Fractal Antenna.*

SIMULATION RESULTS AND DISCUSSION

CST deals with precise effective solutions for electromagnetic design and analysis. It provides broad variety of products for Electromagnetic simulation software to meet design experiments through the electromagnetic spectrum like static, low, microwave and Radio frequency for a wide range of applications.[7]

Therefore, to understand the behaviors of the fractal antenna's structure and to determine the different parameters, the antenna was simulated using CST Microwave studio software 2010, which is very compact in size. The return loss curve of fractal antenna that is Reflection coefficient V/s Frequency curve was plotted and depicted in Figure 3 which has very wide frequency band from 1.875 to 2.733 GHz, operating at center frequency about 2.094 GHz and gain about 52.32 db. The bandwidth of antenna is about 876 MHz as shown in figure. This return loss was determined with the help of CST Software version 2010. Here Pointer 1 shows the maximum value of return loss at operating center frequency 2.094 GHz. Pointer 2 and Pointer 3 shows the bandwidth of antenna. Front and back view structure of star shaped star slotted fractal above Figure 1 and 2.

Figures 4 and 5 show Polar plot and Smith chart curve respectively. Dimensions of antenna are already shown in Figure 1 and 2 which is very compact in size. This is a novel star shaped star slotted design and a circular slot is made in midway on main structure of antenna.

In Figure 4, pointer 1 shows the value of cut off frequency at center which is 2.094 GHz. This plot is drawn for the frequency range 0–3 GHz and both frequencies 0 and 3 GHz are depicted in figure by two dots one is dark at about 0.25 and another is transparent which is shown in the perfect unity value. This plot was also drawn with the help of CST simulation software

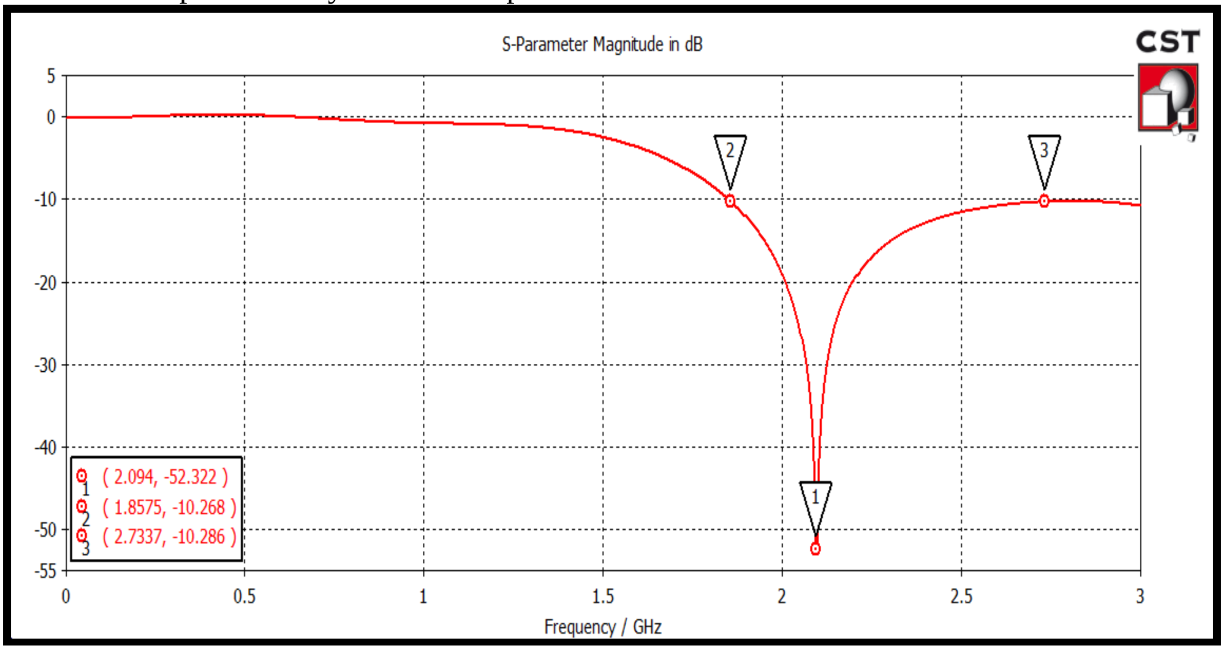

Fig. 3: *Return Loss of Proposed Fractal Antenna.*

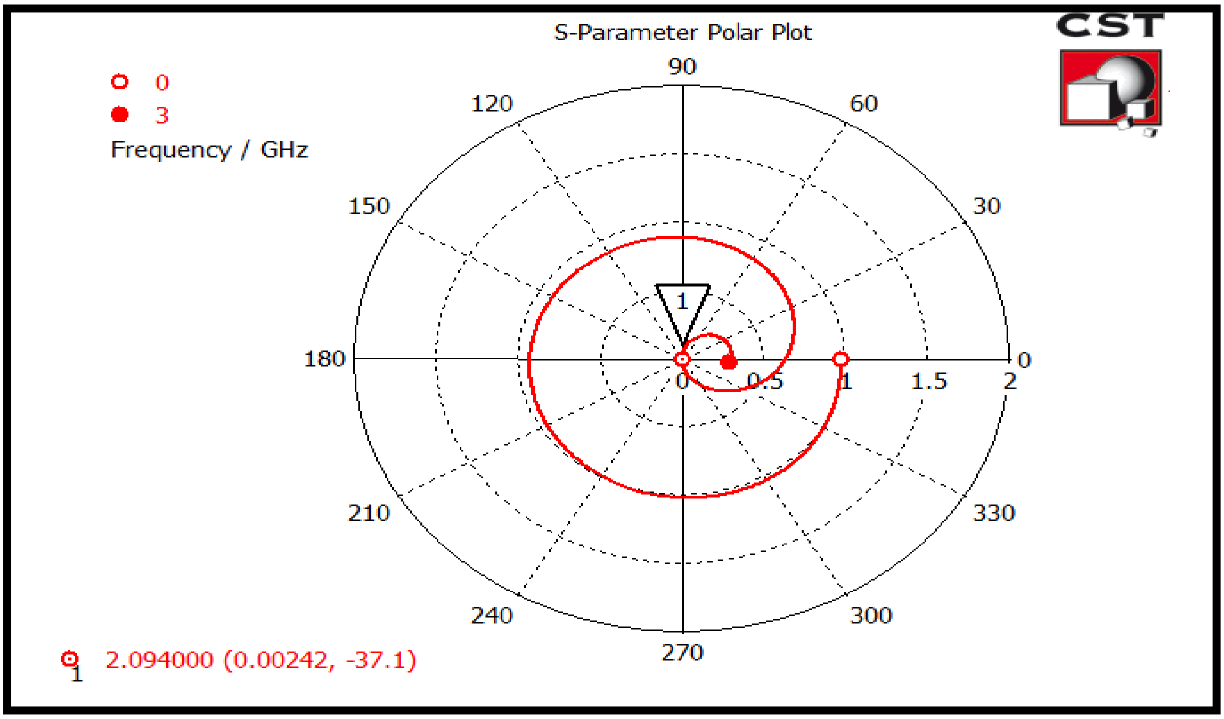

Fig. 4: *Polar Plot of Proposed Star Shaped Iterated Fractal Antenna.*

Smith chart curve of proposed star shaped star slotted fractal antenna is shown in Figure 5. For perfectly matched antenna the value of impedance should be purely resistive and reactive part should be zero. In this proposed star shaped star slotted fractal antenna value of impedance is approximately about 50 Ohm and reactive part is very low which negligible. This chart of proposed antenna was calculated with the help CST software. Both of these curves satisfy the appropriate condition for a perfect antenna.

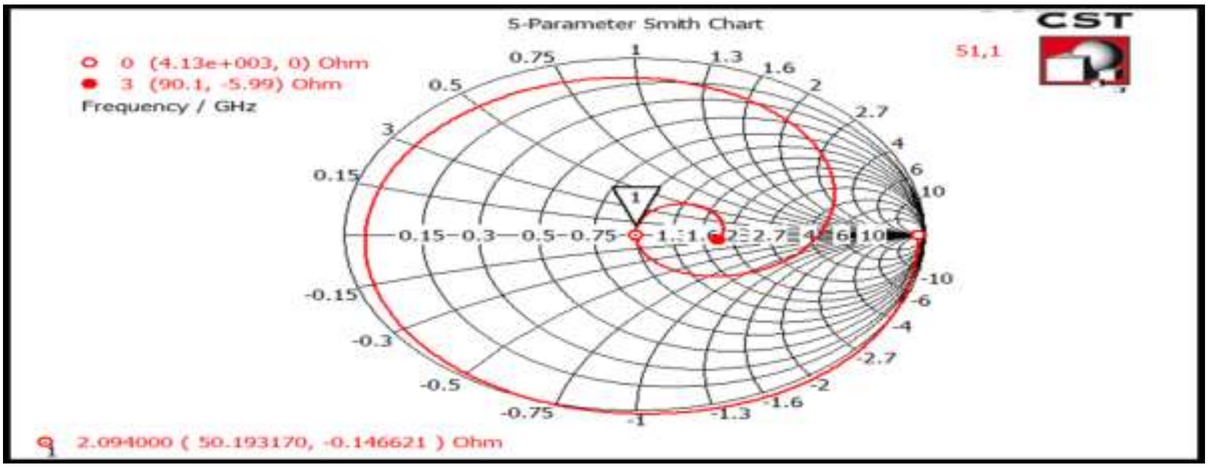

Fig. 5: *Smith Chart of Star Shaped Fractal Antenna.*

Voltage standing wave ratio curve (VSWR vs Frequency curve) of star shaped iterated star slotted fractal antenna is shown in Figure 6, respectively. For perfect antenna VSWR should be approximately equal to unity at cut off frequency, which is clearly shown in figure but practically unity value of voltage standing wave ratio is not possible. This star shaped fractal antenna has VSWR value 1.0049 at center frequency which is approximately equal to unity. Polar radiation pattern of proposed star shaped star slotted iterated fractal antenna is shown in Figure 7 at center frequency of 2.094 GHz. The curve is plotted as theta/degree versus dB at frequency of 2.094.

Figures 8 and 9 show the three-dimensional radiation pattern of proposed fractal antenna. In Figure 8 the Absolute radiation pattern of antenna at cut off frequency is shown. Figure 9 shows the Angular radiation pattern of antenna. Both these three dimensional radiation pattern of antenna are transparent type at determine at center operating frequency 2.094 GHz. This antenna has radiation efficiency about 96%.

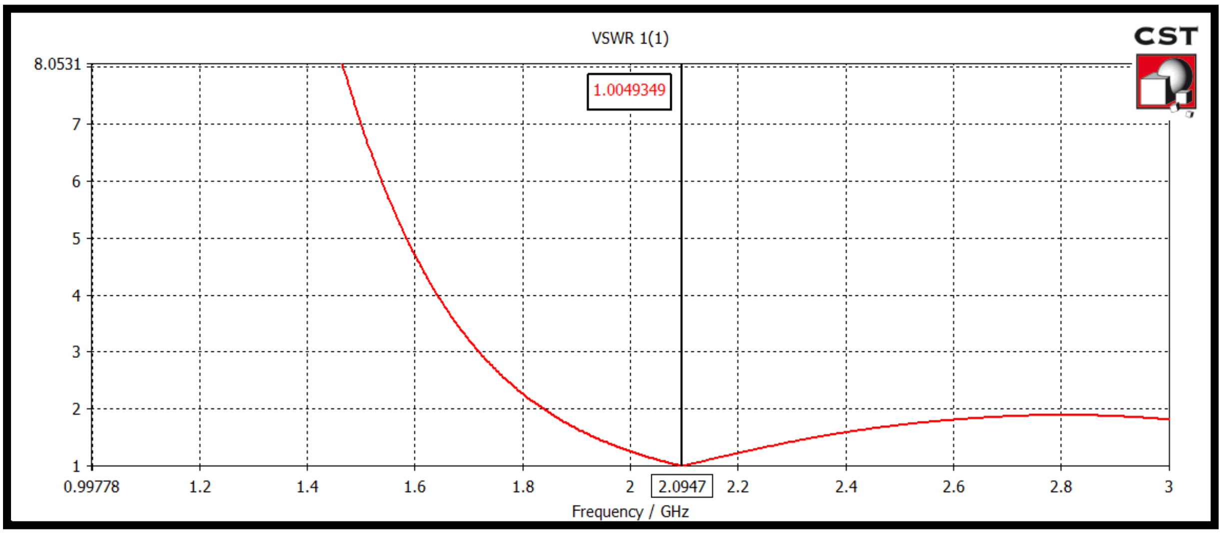

Fig. 6: *Voltage Standing Wave Ratio of Star Shaped Fractal Antenna.*

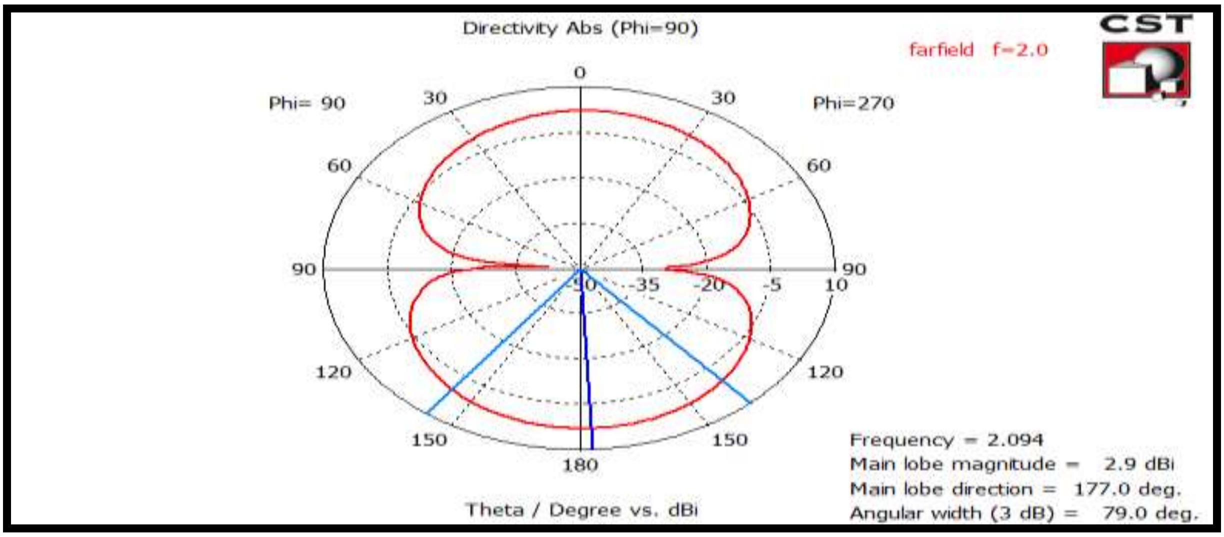

Fig. 7: *Measured Radiation Pattern of Star Shaped Fractal Antenna.*

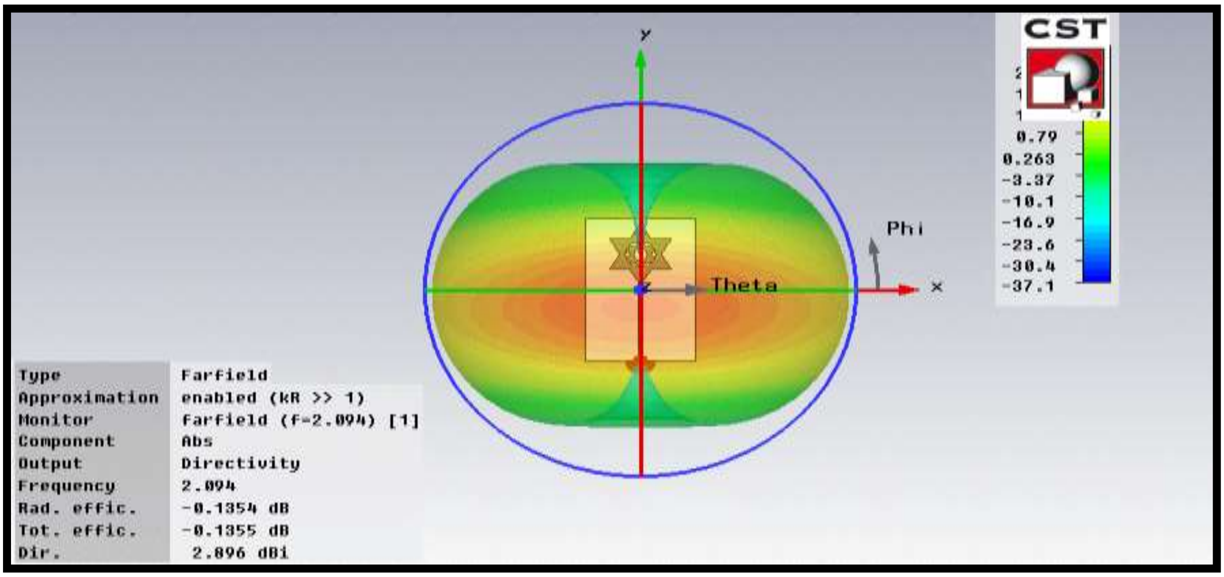

Fig. 8: *Absolute Radiation Pattern of Proposed Fractal Antenna.*

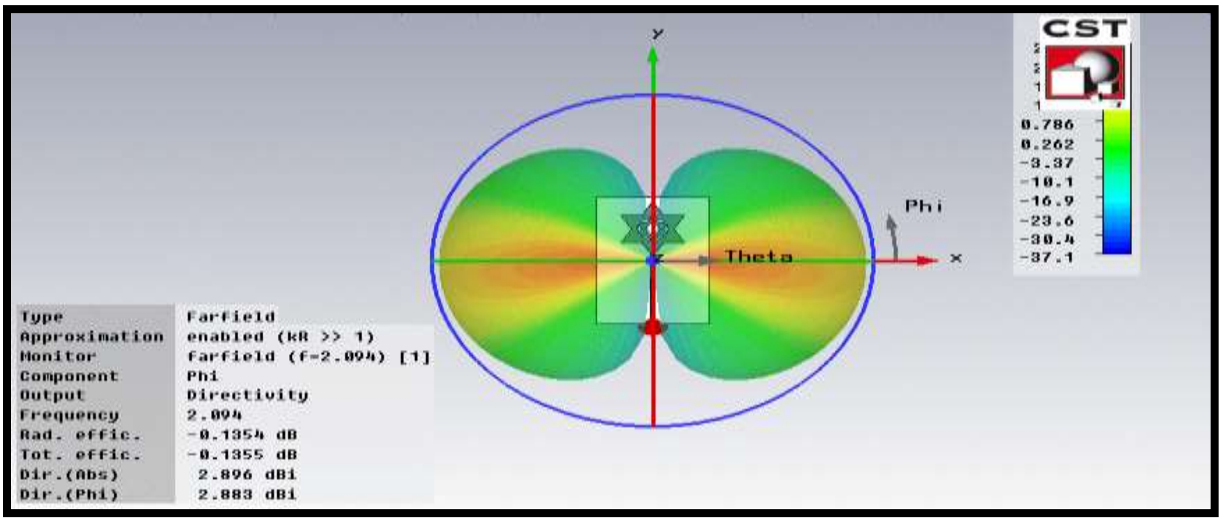

Fig. 9: *Angular Radiation Pattern of Star Shaped Fractal Antenna.*

APPLICATION

Basically antenna is used for transmitting and receiving of electromagnetic waves. In this paper proposed antenna is designed by using fractal geometry. Proposed antenna is used for Wi-Fi (wide-fidelity) because it covers wireless frequency range of Wi-Fi (2.4–2.8 GHz). This proposed antenna has very high gain about 52.322 dB and high bandwidth 876 MHz (1857 to 2733 MHz). It is a compact size 4×6 cm^2 antenna, so this antenna is useful where light weight and small size antenna is required, i.e., for military and commercial applications.

CONCLUSION

In this paper, a novel design of fractal antenna is given, which has star shaped star slotted iterated structure. This fractal antenna operates at 2.094 GHz frequency and having bandwidth about 876 MHz Gain of antenna also very high about 52 db. Main proposes of designing this fractal antenna is compact size and operates at low frequency than comparison to many fractal antennas and radiation efficiency of this proposed fractal antenna is about 96%, which can be found with the help of Figure 8 by taking antilog of tenth part of the arithmetic value of radiation efficiency. Hence, it is a high gain and compact size fractal antenna.

REFERENCES

1. Budhauliya S., Yadav S., Singhal P.K. Design of modified telecommunications. *J Telecommun.* 2012; 13(1).
2. Lopes M.P. Thesis report on fractal antennas for wireless communication system. *FEUP*. 2009.
3. Baliarda, C.P., Romeu, J., Cardama, A. The koch monopole: a small fractal antenna. *IEEE Trans. Antennas Propag*. 2000; 48(11): 1773–81p.
4. Young J., Peter L. A brief history of GPR fundamentals and applications. *6th International Conference on Ground Penetrating Radar*; 1996: 5–14p.
5. Daniels D.J. *Surface-Penetrating Radar*. 2 Edn. United Kingdom: London: The Institute of Electrical Engineers; 2004: 72–93p.
6. Mandelbrot B.B. *The Fractal Geometry of Nature*. San Francisco, CA: W.H. Freeman; 1983.
7. CST Microwave Studio Software 2010.