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# DESIGN AND ANALYSIS OF MINKOWSKI FRACTAL ANTENNA

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## ABSTRACT

Minkowski technique is proposed in this paper in order to design dual-band microstrip antenna with frequency bands of 1.8 GHz and 2.4 GHz. The conventional microstrip patch antenna has single band in which its return loss is -25.92 dB at 2.4 GHz. The CST simulated results show that when Minkowski fractal microstrip antenna is designed, the antenna operates with two frequency bands for return loss of -19.301 dB and -39.575 dB at 1.8 GHz and 2.4 GHz respectively. The antenna is fabricated on FR-4 substrate with permittivity of 4.3 and thickness of 1.6 mm.

**Keywords:** minkowski, fractal antenna, dual-band.

## INTRODUCTION

In view of the progress of the recent communication systems and increase in application areas with vital requirements such as small size, less weight and better performance, the miniaturized multiband antennas are in great demand. Microstrip antennas are a class of miniaturized antennas with many advantages like light weight, conformability, low cost etc. For simple radiating patch shapes, the design can be carried out easily [1]. There remain many methods for the design of antennas for various applications and improving their performances [2]. The conventional antenna designed for broadband applications suffer from space for size and restricted bandwidths. However, there have been several efforts worldwide to bring together the fractal geometry with electromagnetic theory. These have led to a plethora of new and innovative antenna designs such as Minkowski fractal.

In many cases the use of fractal antennas can simplify circuit design, reduce construction costs and improve reliability. Furthermore they are self-loading, no antenna parts such as coils and capacitors are needed to make them resonant. Arranging the elements in a fractal pattern to reduce the number of elements in the array and obtain wideband array for multiband performance [3-4]. Consequently, fractal shape antennas are becoming a useful way to design advanced antennas such as multiband antennas with approximately the same input characteristics for different frequency bands and also as small size antennas [5-7]. This paper deals with the design and analysis of dual band Minkowski fractal antenna.

This paper contains four sections, in section two; the configuration of the antenna is elaborated. The results and discussion are highlighted in the third section, while the conclusion of this paper is summarized in the fourth section and then followed by a reference part.

## DESIGN OF THE ANTENNA

The proposed antenna is designed in commercially available Computer Simulation Technology (CST) software. The antenna is designed on FR-4 substrate with permittivity of 4.3 and thickness of 1.6 mm. This is preferred because of ease of fabrication and availability. The design of the conventional square microstrip patch antenna is shown in Figure 1. The width and length of the antenna are calculated using equations found in [8]. By using these equations the antenna parameters such as width and length are optimized to 38.39 mm and 29.778 mm respectively. The antenna is fed using 50 Ω coaxial probe. The conventional microstrip antenna is shown in Figure-1.

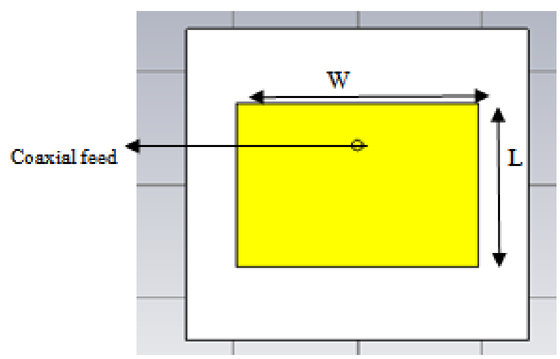


**Figure-1.** Configuration of Square microstrip patch antenna.

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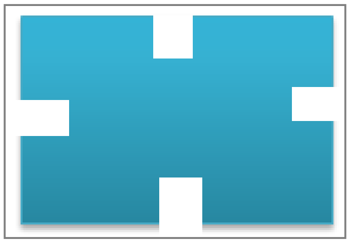
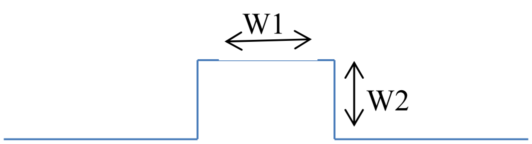


(a)




(b)

**Figure-2.** Proposed antenna of zero and 1st iteration of Minkowski fractal antenna.

The application of fractal geometry to conventional antenna structures optimizes the shape of the antennas in order to increase their electrical length, which thus reduces their overall size. Though different fractal geometries are available, a very few can be used in the design of microstrip antennas. One such geometry is Minkowski fractal antenna. Minkowski iterations produce a cross-like fractal patch with even more fine details at the edges as shown in Figure-2.

## RESULTS

S-parameter narrates the input-output relationship between ports in an electrical system. S11-parameter indicates maximum reflection of power from the antenna, hence it is also known as reflection coefficient or return loss (Γ). The proposed conventional and Minkowski fractal antennas were simulated in CST Microwave Studio using Time domain solver. The antenna was fed using coaxial feeding. The comparison between the S11 of the two antennas is shown in Figure-3. First, the conventional microstrip square patch antenna is designed in CST and its return loss is shown in Figure-3.

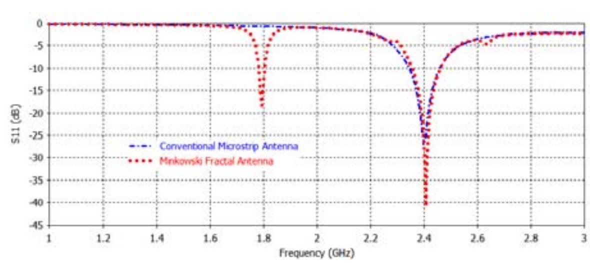



**Figure-3.** Return loss of simulated conventional microstrip patch and Minkowski fractal antenna.

As it can be seen from Figure 3 the conventional antenna operates single frequency band of 2.4 GHz with a return loss of -25.92 dB better than -10 dB. While Minkowski fractal antenna operates at dual frequency bands of 1.8 GHz and 2.4 GHz with return loss of -19.301 dB and -39.575 dB respectively.

The comparison between the gain of the conventional and Minkowski fractal microstrip antennas is shown in Figure-4. The conventional antenna has a gain of 8.77 dBi at 2.4 GHz only. While the Minkowski fractal antenna has gain for dual bands, for example 7.13 dBi and 8.75 dBi at 1.8 GHz and 2.4 GHz respectively.

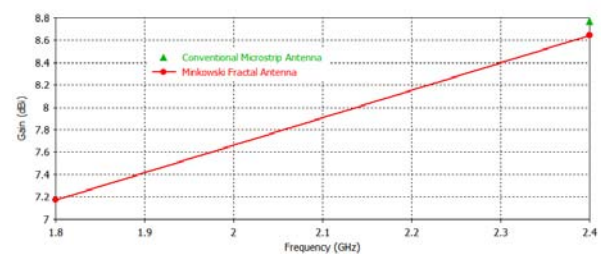



**Figure-4.** Comparison between simulated gain of conventional microstrip patch and Minkowski fractal antennas.

Figure-5 shows the 3D view of radiation pattern in theta component of conventional microstrip patch antenna. While Figure-6 (a) to (b) shows the radiation pattern of Minkowski fractal antenna operating at frequency of 1.8 GHz and 2.4 GHz. As it can be observed from all simulated pattern results, the proposed antenna has linearly polarized uni-directional characteristics.

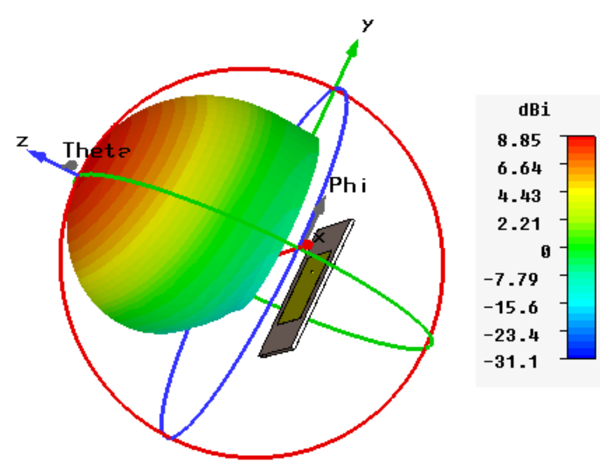



**Figure-5.** 3 D radiation pattern at 2.4 GHz for conventional microstrip antenna.

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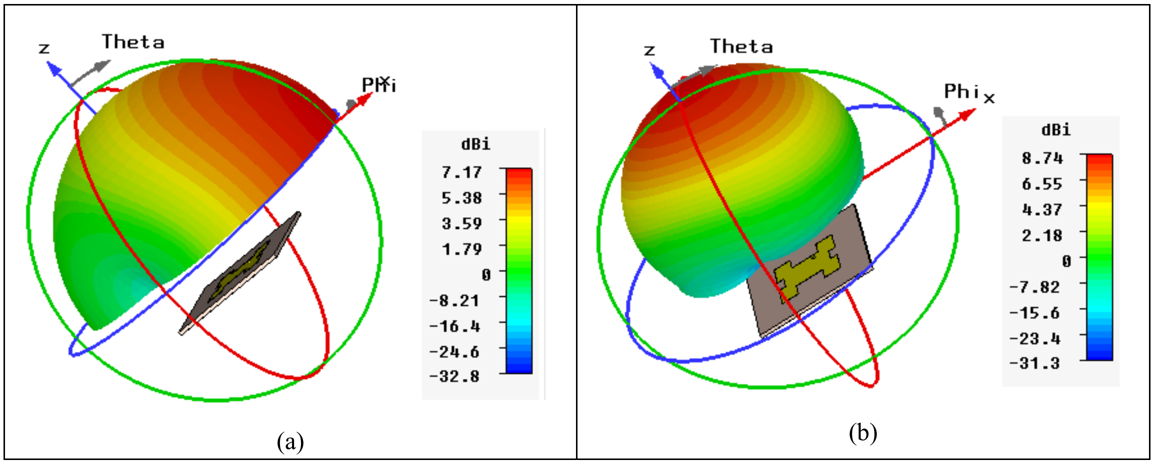


**Figure-6.** 3 D radiation pattern of Minkowski fractal antenna at (a) 1.8 GHz and (b) 2.4 GHz.

The comparison between radiation efficiency of the conventional microstrip and Minkowski fractal antennas is shown in Figure-7. The radiation efficiency of the conventional antenna is 88.12% at 2.4 GHz. While Minkowski fractal antenna has dual band and its radiation efficiency is 74.28% and 17.35% at 2.4 GHz and 1.8 GHz respectively. Finally, the summary of the performance of the conventional and Minkowski fractal antennas is shown in Table-1.

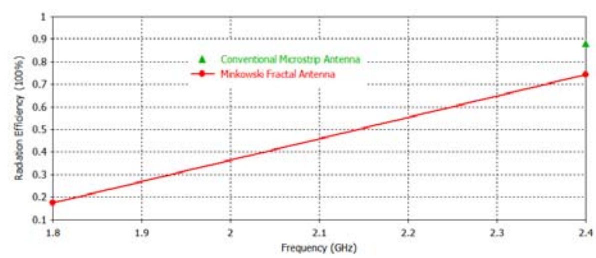


**Figure-7.** Comparison between simulated radiation efficiency of conventional microstrip patch and Minkowskifractal antennas.

**Table-1.** Performance comparison between conventional and fractral antennas.

| Parameter | Conventional antenna | Minkowski fractal | |
|---|---|---|---|
| Frequency | 2.4 GHz | 1.8 GHz | 2.4 GHz |
| S11 (dB) | -25.92 | -19.301 | -39.575 |
| BW (MHz) | 16.75 | 22.03 | 21.67 |
| Gain (dB) | 8.77 | 7.13 | 8.75 |
| Radiation efficiency | 88.12% | 17.35% | 74.28% |

## CONCLUSIONS

The design of dual-band microstrip antenna with Minkowski shape at frequency bands of 1.8 GHz and 2.4 GHz is presented in this paper. The Minkowski technique is proposed in order to achieve the dual band operation of the antenna. The conventional design antenna has single band operating with return loss of -25.92 dB of better than -10 dB. However, by employing Minkowski technique, the antenna has dual band operation with return loss of -19.301 dB and -39.575 dB at 1.8 GHz and 2.4 GHz respectively. Finally, the gain of Minkowski fractal antenna is 7.13 dB and 8.75 dB with radiation efficiency of 17.35% and 74.28% at 1.8 GHz and 2.4 GHz respectively as shown in Table-1.

## ACKNOWLEDGEMENT

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