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Design and Analysis of 64 GHz Millimetre Wave Microstrip Patch Antenna

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Abstract. Millimetre Wave frequencies (30-300 GHz) can be used for different major applications of modern world like telecommunications, security screening, imaging, automotive radars, military applications, remote sensing, radio astronomy and many more. The internationally reserved frequency spectrum is used for Radio Frequency Energy. In this work 64 GHz antennas are compared with different design and a comparative study is taken. In this work Microstrip patch antenna with carpet architecture, and fractal island are designed and compared. The general comparative parameters for antenna are directivity, gain, return loss, bandwidth, specific absorption rate etc. After the comparison, it is found that return loss gave better result for carpet design at 64 GHz compare to fractal island design.

Keywords. Millimetre Wave Antenna, ISM band, Carpet Antenna, Fractal Island, Microstrip Patch Antenna

1. Introduction

In modern age, the design of Microstrip Patch antenna plays a major role in RF industry. After the major pandemic, no body of us can deny the relevance of communication. Antenna is the heart of the communication which is working as a transducer to convert electrical signal to electromagnetic signal in the transmitter side and vice versa in the receiver side. Different antennas have its own frequency of applications and designs. Microstrip Patch antenna got more popularity based on its compact size, low cost and other useful major parameters. The carpet and fractal island design were fabricated on basic Microstrip Patch Antenna. Fractal and Metamaterial can enhance the performance of the antenna as discussed in literature.

2. Literature Review

In literature different antenna shapes like pentagonal, octagonal, hexagonal [1] are furnished with different return loss. Metamaterial and Fractal structure [2] can also be used for enhancing the antenna performance.[3]. In modern age, the design of Microstrip Patch antenna plays a major role in RF industry. After the major pandemic, no body of us can deny the relevance of communication.

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Design Specifications

The basic design for carpet design and fractal island design is the design of microstrip patch antenna [7]. The basic design specifications are explained below.

1. Mathematical Modeling for Square Patch Antenna

Patch Width $(w) = \frac{c}{2} * \frac{1}{fr} * \sqrt{\frac{2}{\varepsilon r+1}}$ (1)

Where c=free space velocity of light=3 x 10^{10} cm/sec

fr =Resonating Frequency=64 GHz

εr=permittivity=4.4

Patch Width is **1.43 mm**

Effective Permittivity

Eeff $= \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2} * {}^{-1}\sqrt{\left(1 + 12 * \frac{h}{w}\right)}$ (2)

Effective permittivity is **3.148 mm**

Effective length of the patch

$L_{eff} = \frac{c}{2} * 1/fr\sqrt{Eeff}$ (3)

Where c= velocity of light (Free Space) =3 x 10^{10} cm/sec

Resonating Frequency=64 GHz

Eeff=Effective permittivity =3.148 mm

Effective length of the patch is **1.32 mm**

Change of Length

Del L$=0.412 * h * \frac{Eeff+0.3}{Eeff-0.258} * \frac{\frac{w}{h}+0.264}{\frac{w}{h}+0.8}$ (4)

Change of Length is **0.5375 mm**

Length of the patch L=L_{eff}-Del L (5)

Length of the patch is **0.7825 mm**

Table 1. Antenna Parameters

Antenna Design parameters	Value
Resonance Frequency (Basic Square Patch)	64 GHz
Substrate	FR4 Epoxy
Height of the patch	1.6 mm
Permittivity	4.4
Length of one side of Square patch	**1.43 mm&0.7825** mm (for rectangular patch) Theoretical

3. Discussions about Results

In this part the design aspects of different microstrip patch antenna are going to be explained elaboratively. Microstrip Patch antenna is the basic building block of all derived design shown in Figure 1. In this work carpet design and fractal island on top of microstrip patch antenna are designed with 64 GHz frequency. Both the designs are compared.

A. Sierpinski Carpet Antenna Design

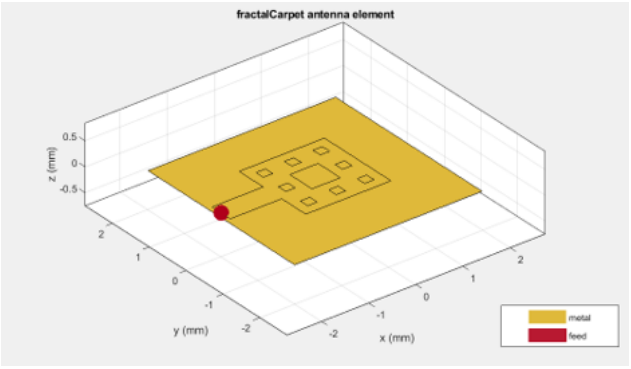

Figure 1. 64 GHz Carpet Design on Microstrip Patch Antenna

Fractal geometry with Electromagnetic theory is a very attractive antenna design. In this work Sierpinski Carpet Antenna Design is added with microstrip patch antenna to get better result is shown in Figure 1.

Antenna Impedance is the relationship between current and voltage at the input of the antenna. It has two parts. One is real and another one is imaginary. Real parts represent the power that is either absorbed or radiated, whereas imaginary part tells us the power that is reserved in the near field of the microstrip patch antenna.

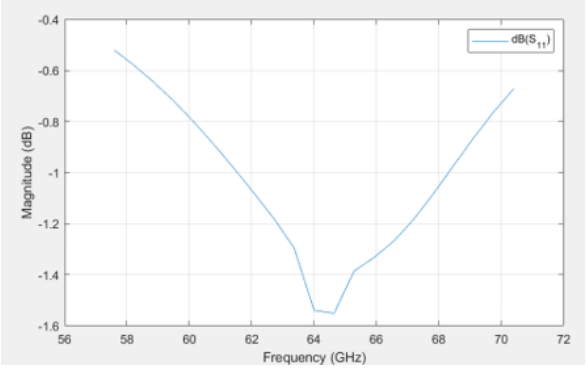

Figure 2. Return Loss of the recommended Microstrip Patch Antenna

The designed antenna Return Loss is 1.6 at 64 GHz. It can be further improved by changing the fractal design is shown in Figure 2.

B. Minkowski Fractal Island Antenna Design

The performance of the Microstrip Patch Antenna can be enhanced by introducing Minkowski Island design on the top of the existing antenna is shown in Figure 3.

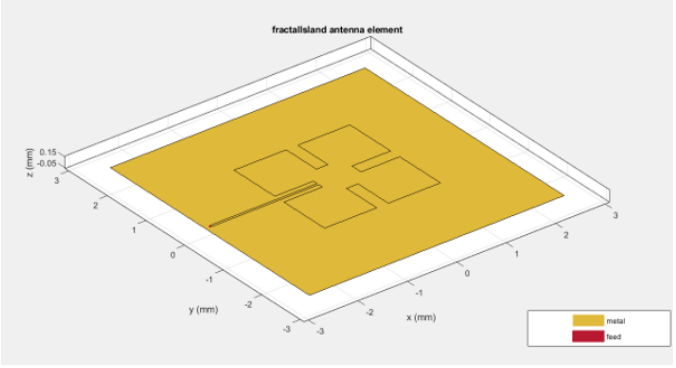

Figure 3. 64 GHz Minkowski Fractal Island Antenna

In this work four carpet structures are introduced in the microstrip patch antenna.

The Real and imaginary part of the impedance perfectly cross each other at 64 GHz .

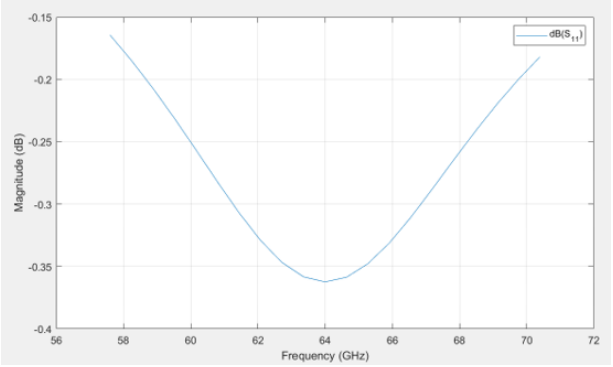

Figure 4. Return Loss of Fractal Island Antenna

Compare to Carpet antenna, return loss is reduced in Fractal Island antenna. But smoothness and perfection nature of the output make the design better than the carpet design is shown in Figure 4.

The current distribution of Fractal Island antenna has poor quality of distribution compared to carpet design. Radiation pattern shows the distribution of the field for fractal island antenna

5. Conclusion

In this work, 64 GHz Carpet antenna and fractal Island antenna are designed and compared. It is shown that the performance of the carpet antenna is better than fractal island antenna in different aspects. The performance of both the antenna can be further enhanced by using the number of iterations. Fractal design is very much promising to add with antenna technology to enhance the performance of the antenna.

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