A double square slot antenna with fractal geometry at 2.4GHz for wifi

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***Abstract*—A double square loop antenna with fractal concepts proposed. The design is based on an initial model of fractal geometry and a double square slot antenna structure. The initial model of fractal geometry influences to the second frequency band and it will be carefully investigated. The radiation patterns of the proposed antenna are still similarly to bidirectional radiation pattern. The properties of the antenna such as return losses, radiation pattern and gain have been carried out via numerical simulation and measurement.**

- Introduction

In the ever-evolving landscape of wireless communication, the demand for high-performance antennas tailored for specific applications has surged. One such application is the ubiquitous WiFi technology, operating at the 2.4 GHz frequency band. To meet the increasing need for efficient and compact WiFi antennas, this report presents the design and analysis of a square loop microstrip feed antenna. The choice of FR4 material with a thickness of 1.6mm offers an affordable and readily available substrate, making it an ideal candidate for consumer electronics. The primary objective of this study is to develop an antenna system that delivers superior performance in terms of gain, bandwidth, and radiation pattern, while adhering to the constraints of compactness and cost-effectiveness.
This report will provide a detailed insight into the design and simulation of the antenna, outlining the key parameters, methodology, and simulation results. The significance of this research lies in the potential to enhance WiFi connectivity in a wide range of applications, from homes and offices to IoT devices, where efficient and cost-effective antennas are paramount. By optimizing the antenna design, we aim to contribute to the advancement of wireless communication technology and facilitate the seamless integration of WiFi into our daily lives.

In today's hyper-connected world, Wi-Fi technology has become the backbone of modern communication systems. It empowers everything from smartphones and laptops to smart homes and IoT devices. At the heart of these wireless networks are antennas, the unsung heroes responsible for relaying data seamlessly through the air. In the realm of Wi-Fi, where high-speed, reliable connectivity is the norm, antenna design becomes a crucial art. This project focuses on the creation of a square loop microstrip feed antenna meticulously engineered for the 2.4 GHz Wi-Fi spectrum. Constructed on a substrate of FR4 with a thickness of 1.6mm, this antenna epitomizes the fusion of cutting-edge RF engineering and material science.

Wi-Fi, a ubiquitous technology, operates within the 2.4 GHz frequency band. In a crowded spectrum, achieving optimal performance, including signal range and penetration, becomes a challenging endeavor.

The square loop microstrip feed antenna emerges as an elegant solution. Its compact form factor, efficient radiation characteristics, and compatibility with FR4 material make it a compelling choice for integration into devices, systems, and infrastructure that rely on Wi-Fi connectivity.

Throughout this project, we will explore the intricacies of antenna design, including critical parameters, electromagnetic simulation, and testing procedures. Furthermore, we will delve into the significance of FR4 as a dielectric substrate, discussing how its properties influence the antenna's performance. This antenna design is not just a technical feat but a testament to the pivotal role of RF technology in our digitally connected lives. It represents the synergy of engineering innovation and material science, underscoring the importance of antennas in enabling the Wi-Fi revolution that fuels our world's connectivity.

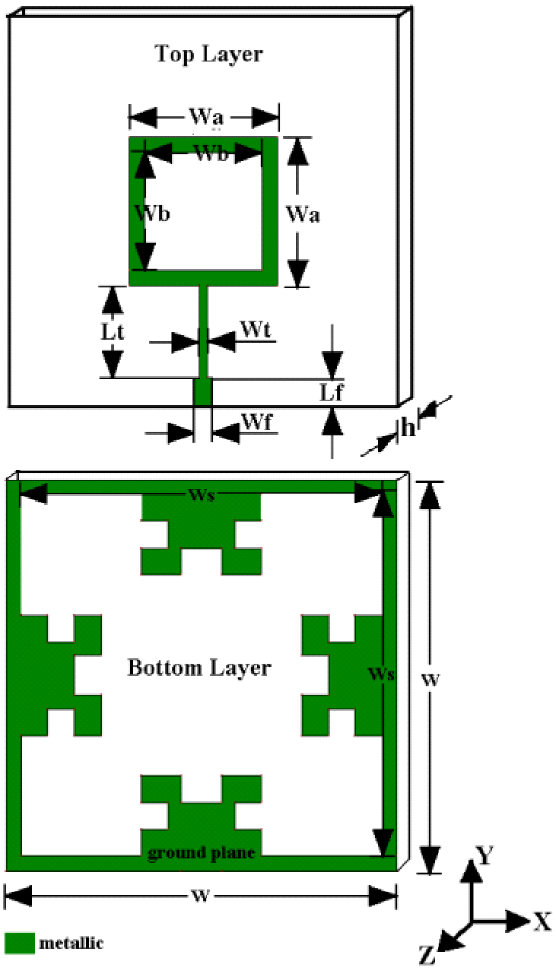


Fig.2: The schematic diagram of the multiband double square loop antenna with fractal geometry.

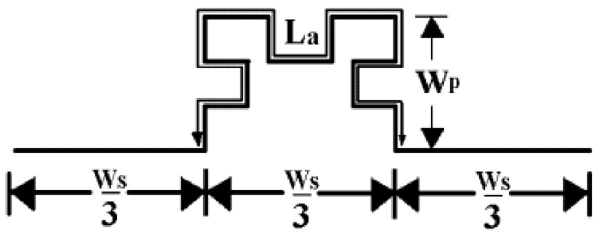
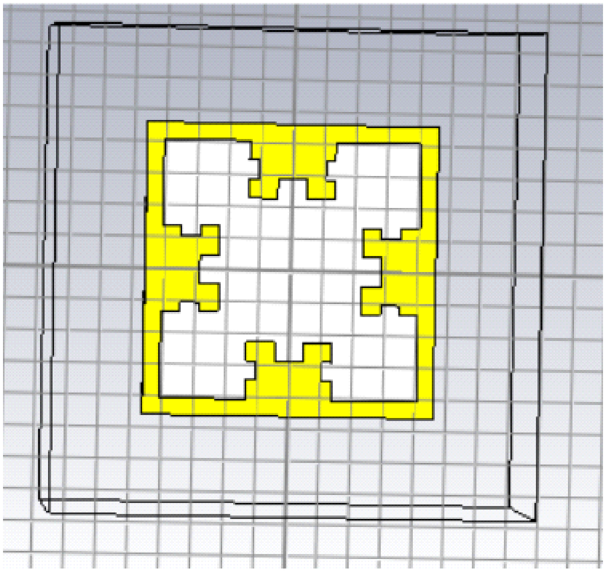


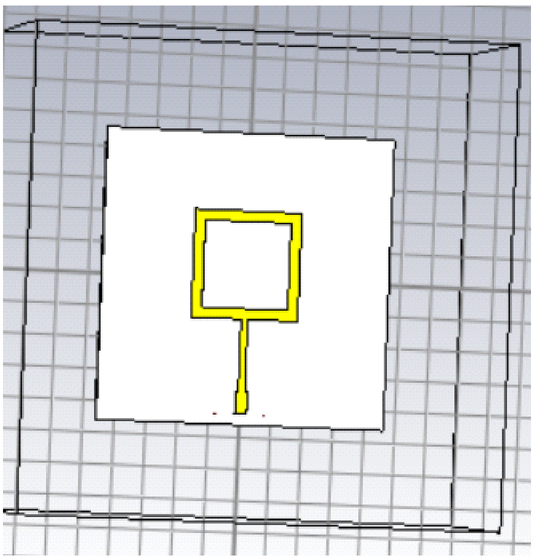
Fig.1: The initial generator model for large slot of antenna.

- *Antenna design*

The proposed antenna in this paper is modified from the fractal ground slot antenna [7]. The height of initial generator model shown in Fig. 1 varies with Wp. Usually, Wp is smaller than Ws/3 and the iteration factor is [8]. The double square slot antenna with fractal geometry is created by the initial model that generates each side of large square slot antenna. The antenna is fed by microstrip line to a small square slot antenna as shown in Fig.2.

The antennas are fabricated on a 1.6 mm thickness FR4 substrate with the relative permittivity İr of 4.4. The total size of proposed antenna is 92x92 mm. The Square loop patch and ground are made of Copper with thickness of 0.035. A 50 Ohm SMA connector is used to feed the antenna at the microstrip line of small square slot antenna. Due to the proposed antenna is too complicated to calculate by using analytical technique, the simulation software CST, is applied to efficiently analyze the characteristic of proposed antenna such as return loss, gain and radiation pattern. The antennas are optimized, resulting in following parameters: h = 1.6 mm, Wp = 18.08 mm, Wa = 31 mm, Wb = 25 mm, W = 92 mm, Ws = 81.40 mm, Wt = 1.93 mm, Wf = 3.46 mm, Lt = 20.75 mm and Lf = 6.49 mm.





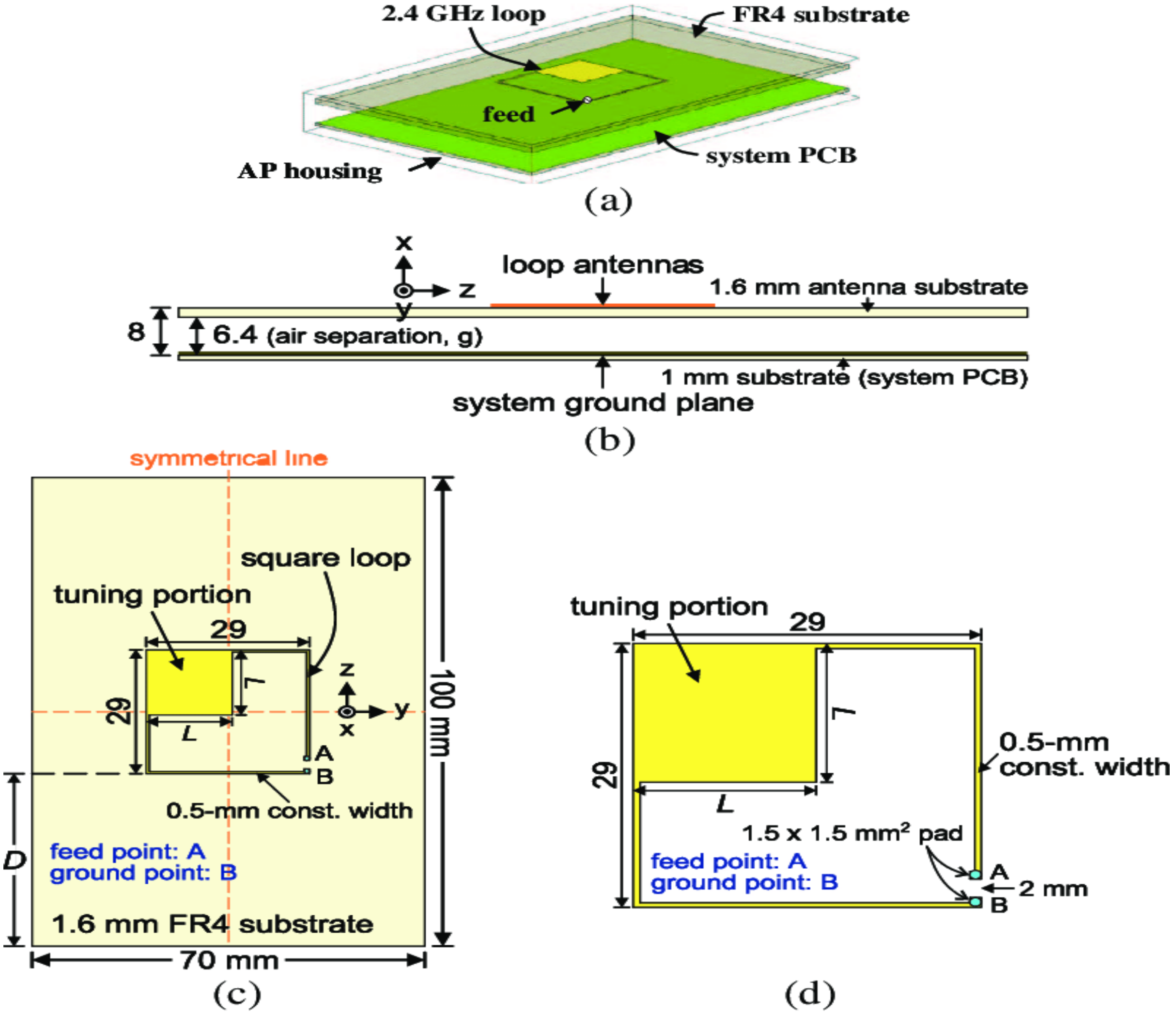
A square loop microstrip feed antenna at 2.4 GHz for Wi-Fi using FR4 material with 1.6mm thickness, we can use the following steps:
Determine the dimensions of the square patch antenna based on the desired frequency of operation. From the search results, we can see that a square microstrip patch antenna has been designed at 2.4 GHz frequency

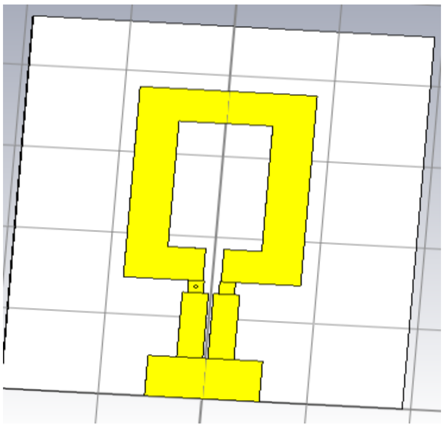
We can use this as a starting point and adjust the dimensions based on the thickness of the FR4 material.
1.Calculate the dimensions of the feed line based on the desired impedance of 50 Ω

2.Determine the dimensions of the square loop that will be used to feed the patch antenna. From the search results, we can see that a square loop antenna has been designed for multi-band operation

. We can use this as a reference and adjust the dimensions based on the desired frequency of operation and the thickness of the FR4 material.
3.Simulate the antenna design using a software tool such as HFSS or CST. This will allow us to optimize the design and ensure that it meets the desired performance parameters such as return loss, voltage standing wave ratio, gain, and radiation pattern

.4.Fabricate the antenna using the FR4 material and test it to verify its performance.
By following these steps, we can design a square loop microstrip feed antenna at 2.4 GHz for Wi-Fi using FR4 material with 1.6mm thickness.



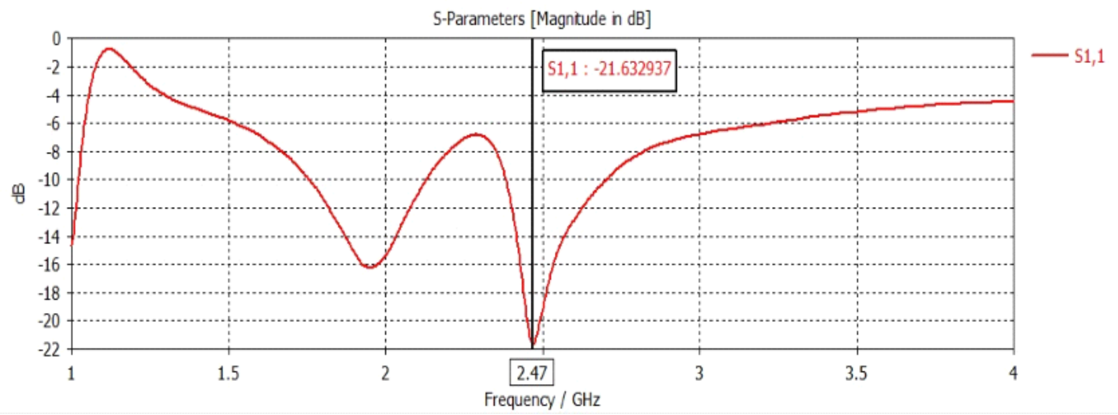


- *Simulation and Experimental Results*

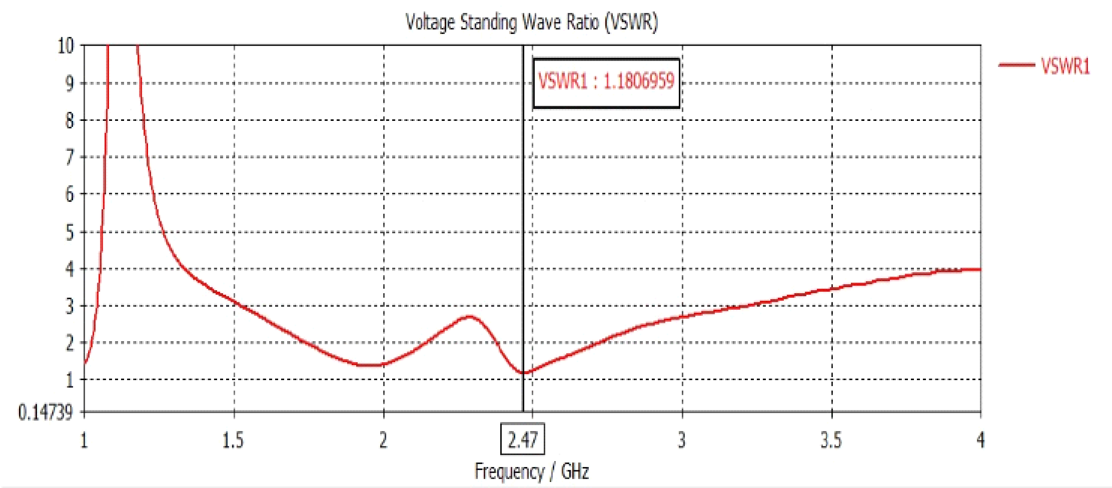
Return loss is a measure of the amount of power reflected back to the source due to an impedance mismatch in a transmission system. VSWR (Voltage Standing Wave Ratio) is a measure of how efficiently radio-frequency power is transmitted from a power source, through a transmission line, into a load.

VSWR should be ideally less than 2, from the simulated data we obtained it to be 1.18.

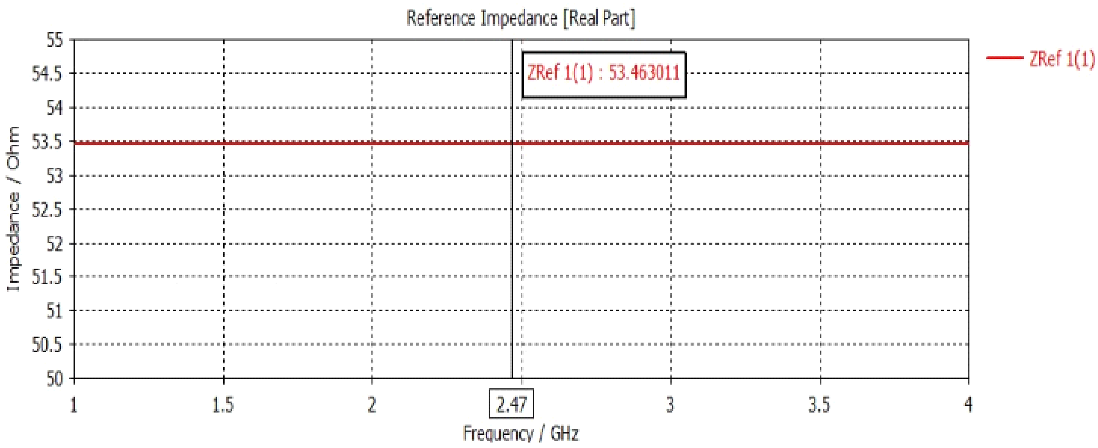
The return loss is obtained to be around -21.36 at 2.47 GHz.



Return Loss



VSWR



Impedance

- Glance Matter on the Antenna Design:

The square loop microstrip feed antenna for 2.4 GHz Wi-Fi is designed to operate within the 2.4 GHz frequency band. It is constructed on an FR4 substrate with a thickness of 1.6mm. The key design parameters include the square loop dimensions, microstrip feed line, and ground plane. The antenna's performance is optimized through simulation and testing to achieve the desired characteristics, such as resonance, gain, and radiation pattern, for efficient Wi-Fi communication.
The use of FR4 material is advantageous for its cost-effectiveness and ease of integration into PCBs, making it a suitable choice for Wi-Fi applications. Additionally, the antenna's compact square loop design is tailored to operate in the 2.4 GHz band, which is a common frequency range for Wi-Fi communications. This antenna design is essential for enabling wireless connectivity in various applications, including home and industrial networks.

- *Conclusion*

This study explored a double square slot antenna featuring fractal geometry. The measured results indicate the antenna's suitability for various mobile communication systems, including SG networks, which predominantly operate in the 2.4 GHz band. By adjusting the antenna's dimensions, specifically La, the second resonant frequency can be tailored to support different mobile communication frequency bands. Further enhancements can be achieved by adjusting the values of Wa and Wo to improve the first resonant frequency.

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