



Sub-6 GHz Dual- Band Microstrip Antenna For 5G NR Bands

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ABSTRACT :

The simulated antenna is a dual-band microstrip antenna with the resonating frequencies at 3.40 GHz and 4.77 GHz. On the lower frequency of 3.40 GHz, the antenna has a great impedance match with a return loss of -35.6 dB along with an associated VSWR of 1.0, which shows almost perfect power transmission from the feed line to the radiator. The 4.77 GHz upper resonance also has good impedance matching with a return loss of about -22 dB and a VSWR of 1.1, and The Gain of the antenna is 2.6dB at 3.40GHz and 3.2 dB at 4.77GHz which is well within the operable range of practical wireless communication systems.

KEYWORDS: hexagonal antenna, meandering, microstrip patch, sub-6, 5G NR bands, gain, impedance matching

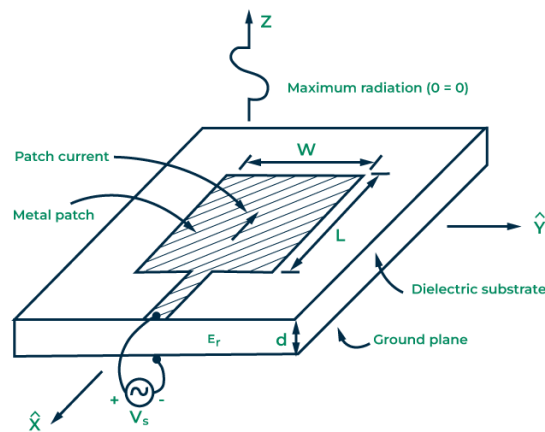
1.INTRODUCTION

1.1. MICROSTRIP ANTENNAS

Microstrip antennas have become some of the most favored printed antennas out there, thanks to their straightforward manufacturing methods and sleek, low-profile design. They fit perfectly with printed-circuit board (PCB) technology, making them a cost-effective choice for large-scale production. Since they first appeared on the scene, these antennas have been widely used in telecommunications, radar systems, direction-finding (DF) systems, and various other RF applications. The idea of microstrip antennas was first put forward by Deschamps back in 1953. However, it wasn't until the late 1960s and early 1970s, spurred by groundbreaking work from Denlinger, Howell, and Munson, that real interest in their design and use took off. A significant breakthrough came in 1977 when Shen and his team formed a round microstrip patch antenna and introduced a method for evaluating the accurate patch radius, considering the effects of fringing fields. This approach was essential for accurately determining the resonant frequency of patch structures. By the early 1980s, the design of microstrip antennas had advanced significantly. Standard design practices and modeling techniques were developed, leading to better performance and optimization of antenna systems. These early advancements set the stage for the widespread use of microstrip antennas in both commercial and military applications.

1.2. PROBLEM STATEMENT

The existing antenna is rectangular microstrip patch antenna with monopole ground, Radiating Patch with thin metallic layer (often copper) printed on top of the dielectric substrate. Its shape rectangular in this case determines the resonant frequency and radiation characteristics. Dielectric Substrate (FR-4) insulating layer between the patch and the ground plane. Its thickness and dielectric constant (ϵ_r) influence bandwidth, efficiency, and size. Ground Plane is conductive layer on the bottom side of the substrate that reflects and supports the radiated fields. Feed Line is Typically, a microstrip line or coaxial probe that delivers RF energy to the patch. The feed position affects impedance matching.



III. PREVIOUS WORK

We have designed a simplified, miniature microstrip-fed square-ring patch antenna that exhibits circularly polarized (CP) radiation [1]. The invented antenna was simulated using the specified design parameters. The results indicate a total impedance bandwidth of approximately 1.1% and a 3-dB axial ratio (AR) bandwidth of about 0.03% at a centre frequency of 1573 MHz. Analysis of the radiation patterns reveals 3-dB beamwidths of around 90°, confirming strong CP characteristics. The simulated and measured results show good agreement. Furthermore, the antenna features a compact and efficient feeding structure, offering adequate CP bandwidth, which makes it well-suited for commercial GPS applications.

This work presents a reflect array antenna design employing hexagonal-shaped unit cells tailored for fifth-generation (5G) communication systems[3]. The hexagonal geometry enables a full 360° reflection phase range, enhancing phase control and design flexibility. The reflect array is implemented using a single-layer topology, which simplifies fabrication, reduces cost, and maintains a compact profile. Simulation results demonstrate a peak gain of 27 dBi at an operating frequency of 28 GHz, aligning with the 5G millimetre-wave spectrum and confirming the antenna's suitability for high-gain, broadband applications.

We introduce a frequency-agile microstrip patch antenna design, incorporating a U-slot in the radiating patch to achieve a even input impedance and a linear input reactance. This configuration enables dynamic adjustment of the matching frequency by modifying the input reactance. A trimmer component is employed to effectively control the input impedance, allowing for frequency tuning. The antenna demonstrates a tunable frequency range with a ratio of approximately 1.28 between the highest and lowest operating frequencies, confirming its suitability for reconfigurable wireless applications.

IV. INVENTED ANTENNA DESIGN

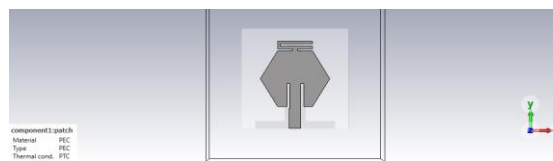


Figure-2: Hexagonal Microstrip Patch with Meandering

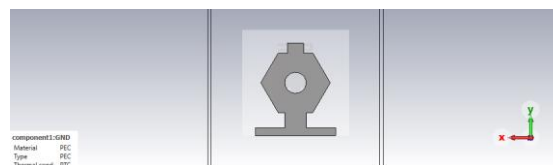


Figure-3: Hexagonal Shaped Ground

3.1 METHODOLOGY

The proposed antenna has hexagonal patch with meandering, the hexagonal shape microstrip patch as more effective and compact size and flexibility. It is polarized circularly in a wireless network over the circular patch; it produced wider bandwidth while using multi-band hexagonal shape patch with meandering with hexagonal shape ground. When using meandering to reduce the resonant frequencies in an antenna, design involves folding or bending the radiating elements into a compact zigzag or serpentine shape, effectively increasing the electrical length while minimizing the physical print. This technique is particularly beneficial for applications requiring miniaturized antennas, such as RFID tags, wearable devices, and IoT modules. By

meandering the structure, designers can achieve resonance at lower frequencies without enlarging the antenna, PEC material is used in the patch with meandering.

Hexagonal ground structure in antenna design offers significant enhancements in presentation metrics such as bandwidth, gain, and impedance matching. This modification introduces a defected ground structure (DGS), which interrupts surface current distribution and enables better control over resonant frequencies. As a result, antennas employing hexagonal ground configurations demonstrate improved return loss, reduced VSWR, and support for dual- or multi-band operation, particularly within sub-6 GHz 5G NR, mobile systems, wireless systems and ISM-band applications.

The invented antenna using Rogers's material for the substrate which is low dielectric loss and minimize the signal attenuation, also helps to improve the S-parameters, VSWR, Gain. Represents the invented hexagonal antenna's outline and radiating patch with meandering. We're looking at the process of combining Rogers with various materials to develop substrates that have both in height and short dielectric properties—think greater bandwidth and small patch dimensions, correspondingly. The maximum layer, which measures just 0.035mm thick and has a relative permittivity of 4.4, is used. The below bench shows the parameters of the invented antenna.

Substrate length	20mm
Substrate width	20mm
Feed Length	11mm
Patch area	16.2x11mm ²
Ground	17x11mm ²

Table-1:Parameters list of invented antenna

4.OUTCOMES AND SIMULATION

The results comparisons the invented antenna compared to other rectangular antenna to calculate performance. The below Figures 5 and 6 shows the design hexagonal patch and rectangular design antenna's reflection coefficient. The difference between base design antenna and suggested antenna design has a greater return loss. The invented antenna resonates in dual band applicable in 5G NR-bands with improved return loss as shown by the proposed hexagonal antenna proposal's return loss of -35.68 dB at 3.40GHz and -20.1dB at 4.77GHz. The following parameters are the simulated they are,

1. **S₁₁ (Scattering Parameter 11):** S₁₁ means the input reflection coefficient of a port network, it calculates the how much power is reflected back from the antenna due to impedance mismatch. The range of the parameters negative (-dB) is good return loss of the antenna. 5G NR designs, aiming for **-15 dB** or better can help ensure reliable performance.
2. **VSWR:** measure of how efficiently RF power is transmitted from a transmitter of antenna through a transmission line, into a load. It quantifies the degree of impedance mismatch between the transmission line and the antenna. A perfect match result in VSWR = 1.0.
3. **GAIN:** Gain measures how effectively an antenna radiates or receives energy in a specific direction, compared to an ideal reference antenna. Expressed in dBs.

Return loss vs Frequency

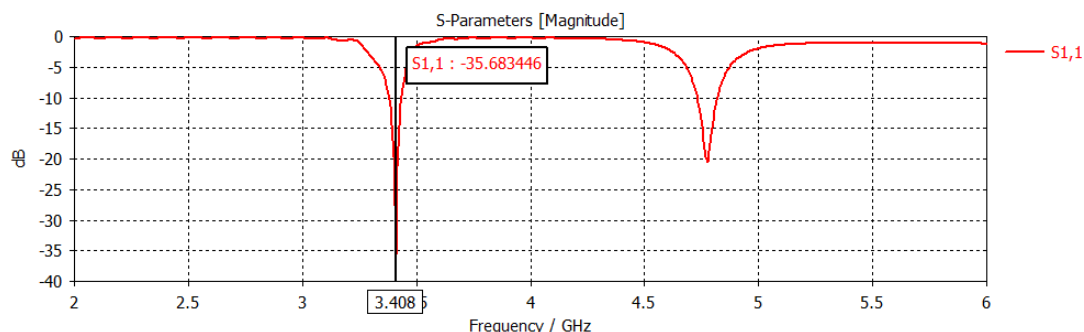


Figure-4: Frequency vs Return losses at 3.4GHz

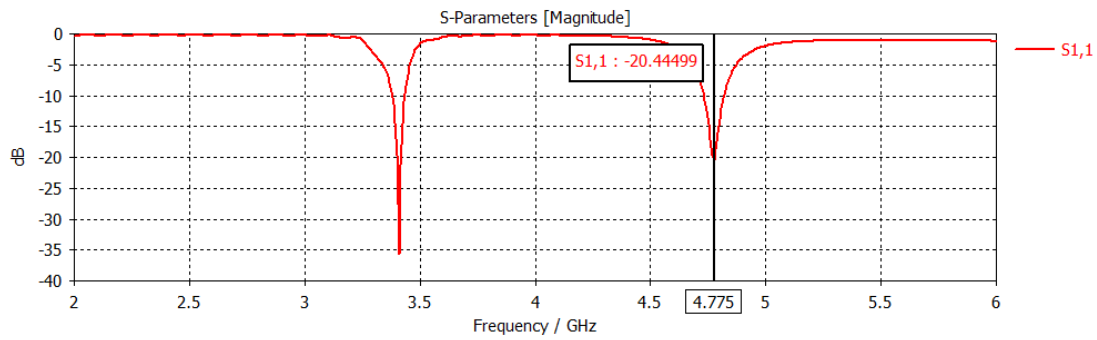


Figure-4.1: Frequency vs Return losses at 4.7GHz

FIG: VSWR

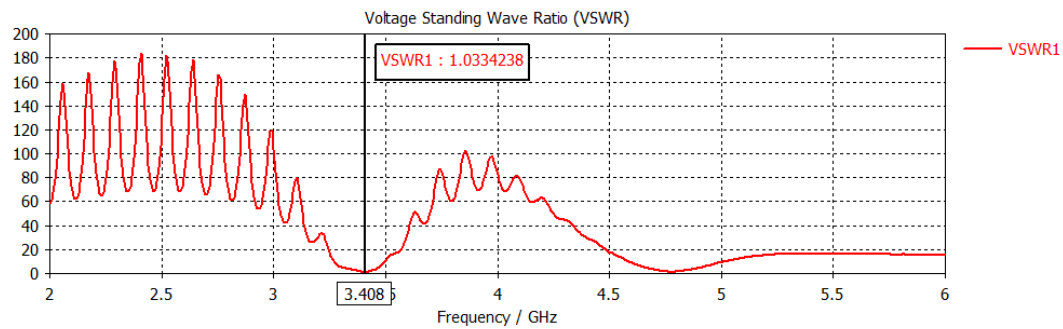


Figure-5: VSWR at 3.4GHz

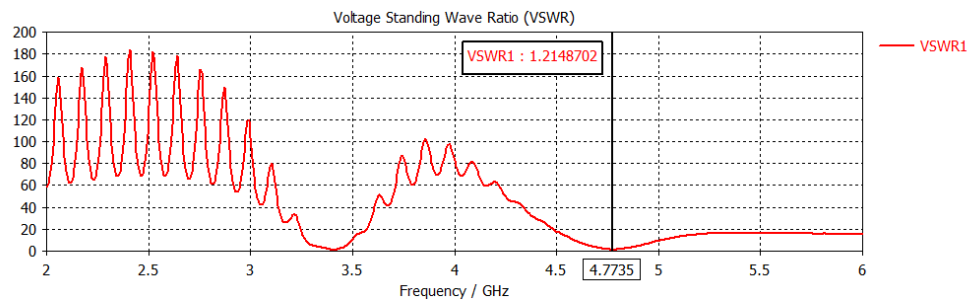


Figure-5.1: VSWR at 4.7GHz

FIG:GAIN-3D PLOT

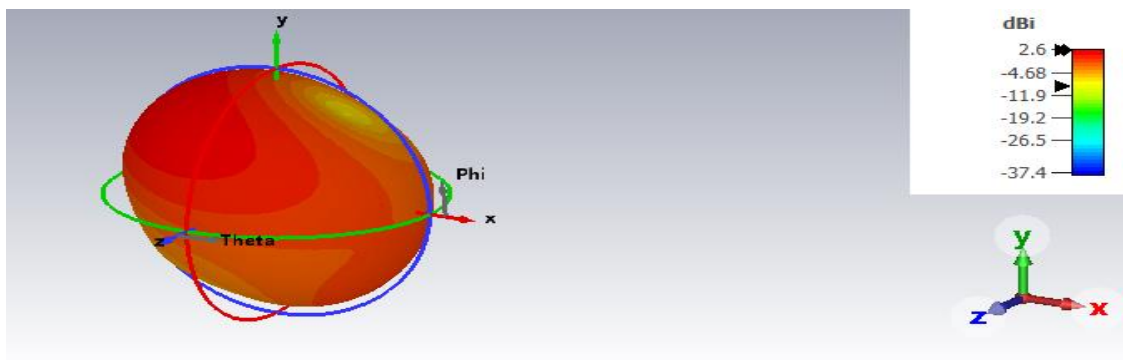


Figure-6 :Gain 3D-Plot at 3.4 GHz

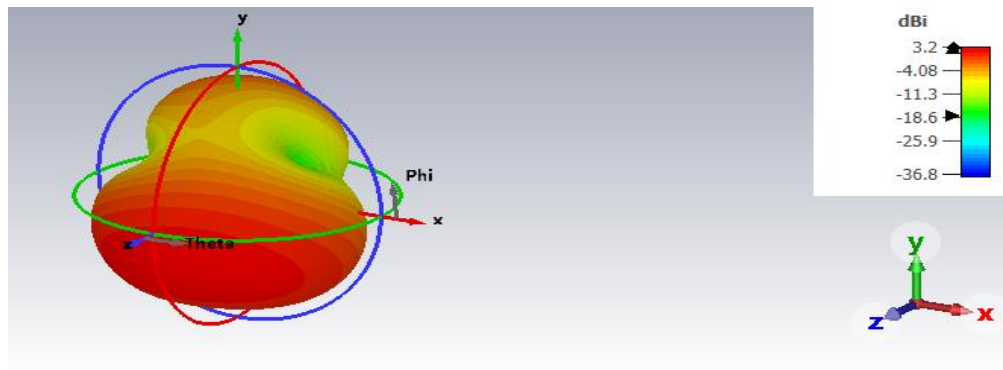


Figure-7: Gain 3D-Plot at 4.7 GHz

The study of the invented Hexagonal antenna along with the present antenna's resonance frequency, bandwidth, and gain tells some interesting perceptions. It turns the invented antenna better and broader bandwidth and a more stable gain related towards the present antenna, as shown in Table 2.

Parameters	Rectangular Micro strip Patch Antenna	Hexagonal Micro strip Patch Antenna (3.4 GHz)	Hexagonal Micro strip Patch Antenna (4.7 GHz)
Frequency	2.4GHz	3.4GHz	4.7GHz
Return loss	-22dB	-34.4dB	-20.19dB
VSWR	1.16	1.05	1.2
Gain	1.4dB	2.6dB	3.2dB
Directivity	4.7dB	4.98dB	5.3dB

APPLICATIONS:

The 3.4 GHz band is the equivalent of current 5G New Radio (NR) services in the n77/n78 band, legacy WiMAX deployments, and fixed wireless broadband. The 4.7 GHz band is allocated to the 5G NR n79 band (4.4–5.0 GHz), which has been largely used in Asia-Pacific nations like China and Japan, and overlaps with the 4.9 GHz public safety band in some countries. Thus, the designed antenna is appropriate for dual-band 5G communication technology with possible applications in broadband wireless access, public safety networks, and future sub-6 GHz applications

FINAL THOUGHTS:

This work boons the design and simulation of a dual-band hexagonal microstrip patch antenna tailored for sub-6 GHz 5G New Radio (NR) applications. The antenna demonstrates resonant behaviour at 3.40 GHz and 4.77 GHz, offering excellent impedance matching across both bands. At 3.40 GHz, the antenna achieves a return loss of -35.6 dB and a VSWR of 1.0, Gain of the antenna 2.6GHz indicating near-ideal power transmission from the feed line to the radiating patch. The upper resonance at 4.77 GHz also exhibits strong performance, through a return losses of -22 dB and the VSWR of 1.1, Gain of the antenna is 3.2GHz well within acceptable limits for practical wireless communication systems. These results validate the antenna's suitability for high-efficiency dual-band operation in emerging 5G infrastructures and wireless system.

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