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High Gain 4x4 Microstrip Rectangular Patch Array Antenna for C-Band Wireless Applications

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ABSTRACT: Microstrip patch antennas are mostly preferred for electronics devices and wireless communication applications. Microstrip patch array antenna is proposed for advance wireless communication application devices by many of the researchers. In this paper, proposed design and Analysis of 4X4 microstrip Patch Antenna Array with DGS for Long Term Evolution Applications at 6GHz frequency range. CST software is used for designing and simulation. FR-4 with dielectric constant of 4.4 and thickness of 1.6 mm is used as a substrate in order to increase the bandwidth. This paper includes designing of a 4X4 rectangular Microstrip patch antenna array with enhanced bandwidth, return loss and gain. Simulated result shows that a DGS concept is also useful to enhance some parameters.

KEYWORDS: Microstrip, Antenna, Array, Pattern, 5G, CST, FR4, VSWR, Return loss.

I. INTRODUCTION

In the realm of wireless communication, antennas play a pivotal role in ensuring efficient signal transmission and reception. The continuous evolution of wireless technologies demands antennas that are not only compact and lightweight but also capable of operating at specific frequency bands. The Microstrip Rectangular Patch Array Antenna has emerged as a noteworthy solution, particularly in the context of C-Band wireless applications.

The C-Band, which spans the frequency range of approximately 4 to 8 GHz, has gained significant prominence for various wireless applications, including satellite communication, radar systems, and point-to-point communication links. The need for high-gain, directional antennas has led to the exploration of innovative designs, and the Microstrip Rectangular Patch Array Antenna stands out as a promising candidate.

The Microstrip Rectangular Patch Array Antenna is based on the microstrip patch antenna design, which involves a radiating patch mounted on a dielectric substrate with a ground plane on the opposite side. This configuration offers advantages such as low profile, ease of fabrication, and compatibility with integrated circuit technology.

An array configuration involves multiple patch elements arranged in a specific geometric pattern. In the case of the Microstrip Rectangular Patch Array Antenna, the patches are arranged in a grid or linear fashion. The array design enhances the overall performance by providing higher gain, improved directivity, and the ability to control the radiation pattern.

Continuous research and development efforts are aimed at further enhancing the performance of Microstrip Rectangular Patch Array Antennas for C-Band applications. Recent advancements include the exploration of advanced materials, metamaterials, and innovative manufacturing techniques to address limitations related to bandwidth and efficiency. The integration of beamforming and phased array technologies is also being investigated to provide adaptive and dynamic control over the antenna's radiation pattern, enabling improved communication in complex and dynamic environments.

Utilizing advanced dielectric materials with unique electromagnetic properties can contribute to expanding the operational bandwidth and improving the overall performance of Microstrip Rectangular Patch Array Antennas. Additionally, advancements in manufacturing techniques, such as additive manufacturing or 3D printing, may further streamline the production process, enabling the creation of customized and intricate antenna designs with higher precision. The integration of beamforming and phased array technologies enables the steering of the antenna's radiation pattern electronically. This capability is particularly valuable in applications requiring adaptive communication, where the direction of the transmitted or received signal needs to be dynamically adjusted. The integration of these technologies enhances the antenna's versatility and adaptability to varying communication scenarios.

To address the growing demand for versatile antennas, researchers are exploring multi-band and dual-polarized designs. These approaches allow Microstrip Rectangular Patch Array Antennas to operate across multiple frequency bands and support polarization diversity. This is especially beneficial in environments with diverse communication standards and signal propagation conditions. The Microstrip Rectangular Patch Array Antenna for C-Band wireless applications represents a crucial technological solution for modern communication systems. As technology advances, ongoing research and development initiatives continue to refine and optimize these antennas, addressing challenges and unlocking new capabilities. The integration of advanced materials, manufacturing techniques, and beamforming technologies is propelling these antennas into a new era of performance, making them indispensable components in the ever-expanding landscape of wireless communication. The Microstrip Rectangular Patch Array Antenna stands at the forefront of innovation, contributing significantly to the evolution of C-Band wireless communication systems. As the demand for higher data rates, increased reliability, and adaptability grows, the continuous development of these antennas ensures their continued relevance and applicability in diverse and challenging communication environments.

II. PROPOSED ANTENNA DESIGN AND METHODOLOGY

The methodology steps of the proposed research work is as followings-

1. Choose appropriate electromagnetic simulation software capable of modeling 4x4 array configurations. Popular tools like CST Microwave Studio are commonly used for antenna design in the C-Band.
2. **Geometry and Parameters Definition:** Define the geometric parameters of the 4x4 Microstrip Rectangular Patch Array, including substrate material, dielectric constant, patch dimensions, spacing between patches, and feeding mechanisms. Tailor the dimensions to resonate within the C-Band frequency range.
3. **Array Configuration:** Select the array configuration based on the application requirements. For a 4x4 array, consider either a linear or planar arrangement of patches. Optimize the placement and spacing of patches to achieve the desired radiation pattern, gain, and directivity. Account for mutual coupling effects.
4. **Feeding Mechanism:** Choose a suitable feeding mechanism, such as microstrip line feed or aperture coupling, for the 4x4 array. Optimize the feed point locations and impedance matching to ensure efficient power transfer. Implement matching networks if necessary.
5. **Simulation and Optimization:** Utilize electromagnetic simulation software to model and analyze the 4x4 Microstrip Rectangular Patch Array. Conduct iterative simulations to optimize design parameters for high gain, broad bandwidth, and a well-defined radiation pattern. Consider the impact of mutual coupling on array performance.

In figure 1, indicating top perspective of proposed Cluster microstrip patch antenna, one side of a dielectric substrate goes about as an emanating patch and opposite side of substrate goes about as ground plane. Top perspective of a rectangular patch antenna with coaxial feed has. Patch and ground plane together makes bordering fields and this field is in charge of making the radiation from the antenna.

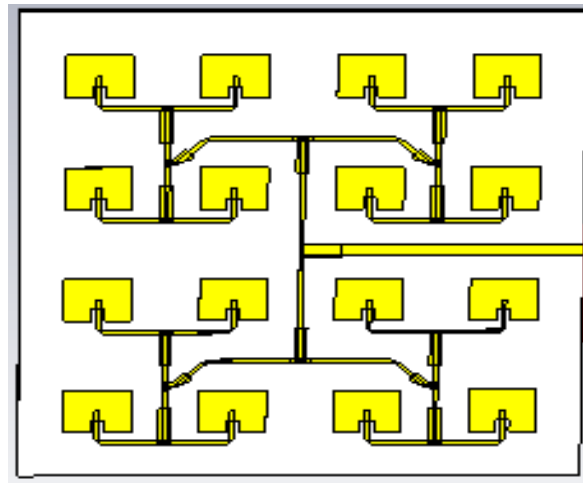


Figure 1: Top view of proposed Array microstrip antenna

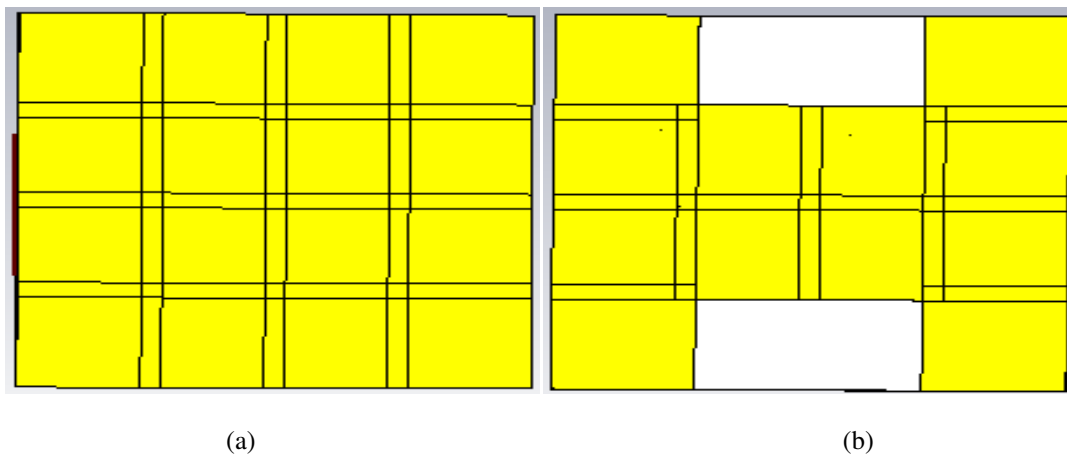


Figure 2 (a) presents the finite ground structure and figure 2(b) presents the defected ground structure bottom view of the proposed microstrip antenna array.

III. SIMULATION AND RESULTS

Proposed antenna design and simulated in CST microwave studio software.

Case-1: Finite ground structure

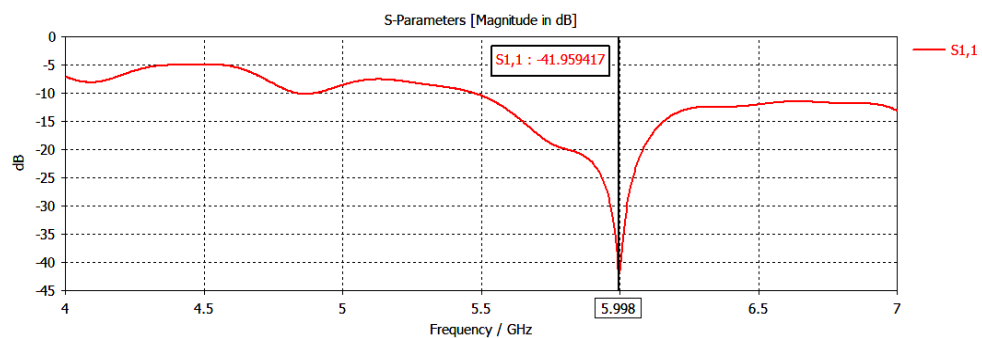


Figure 3: S parameter and Return loss

The bandwidth of an antenna is characterized as "the scope of frequencies inside which the execution of the antenna, regarding some trademark, adjusts to a predefined standard." For broadband antennas, the bandwidth is generally communicated as the ratio of the upper-to-bring down frequencies of adequate operation.

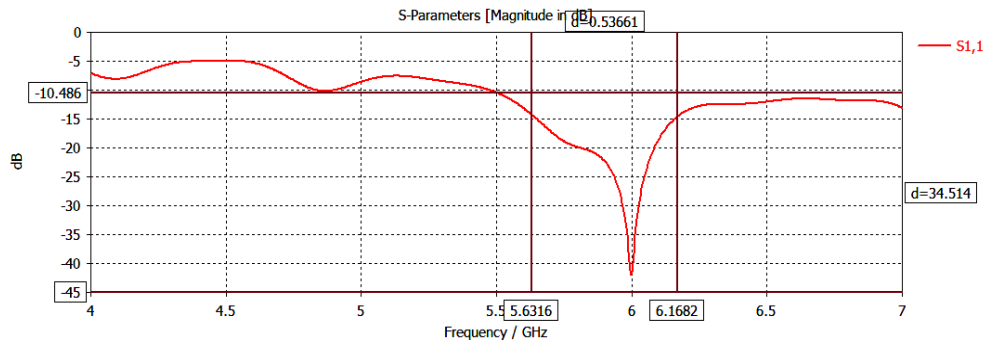


Figure 4: Bandwidth calculation

For broadband antennas, the bandwidth is communicated as a level of the frequency contrast (upper less lower) over the middle frequency of the bandwidth. The bandwidth of proposed antenna is 536 MHz, (6.1682GHz-5.6316GHz).

Voltage Standing Wave Ratio (VSWR)

The most well-known case for estimating and looking at VSWR is when introducing and tuning transmitting antennas. At the point when a transmitter is associated with an antenna by a feed line, the impedance of the antenna and feed line must match precisely for most extreme vitality exchange from the feed line to the antenna to be conceivable.

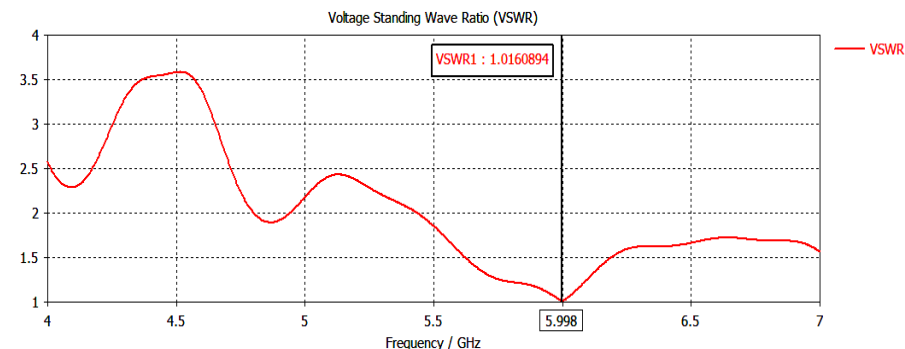


Figure 5: Voltage Standing Wave Ratios

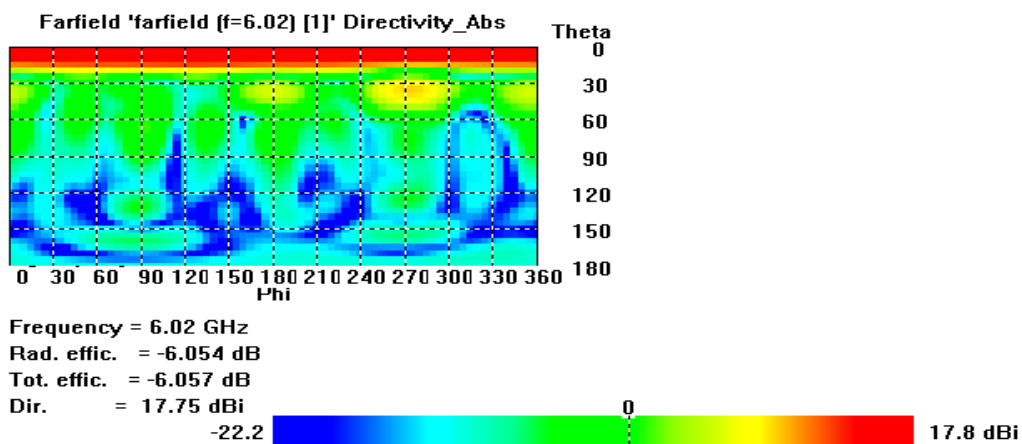


Figure 6: Far field directivity in 2 dimensional scales

Case-2: Defected ground structure

In figure 7, it is seen that, S11 parameter and return loss. They got estimation of S11 for 6.1229GHz is -18.41dB and 6.598GHz is -17.39dB. Here 6.1229GHz and 6.598GHz is resonant frequency, where antenna proficiency is higher.

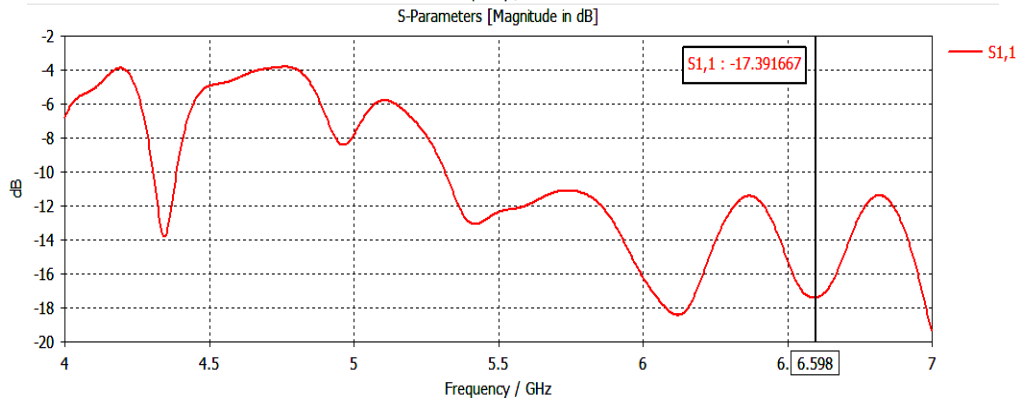
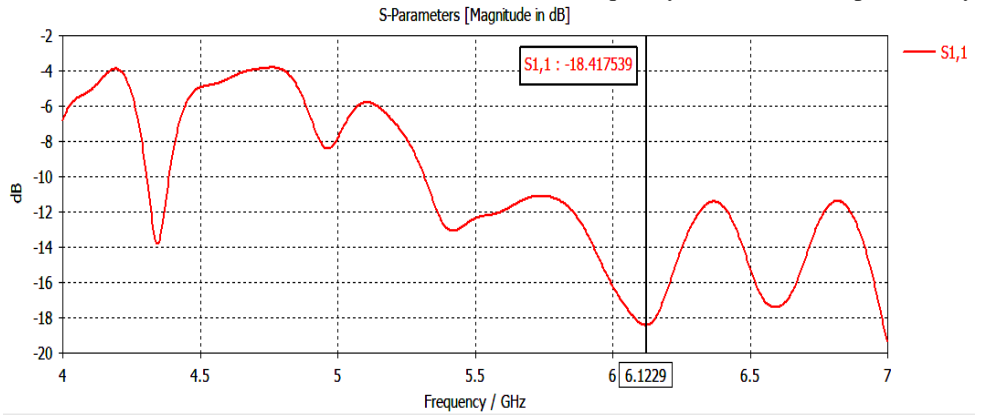


Figure 7: S parameter and Return loss

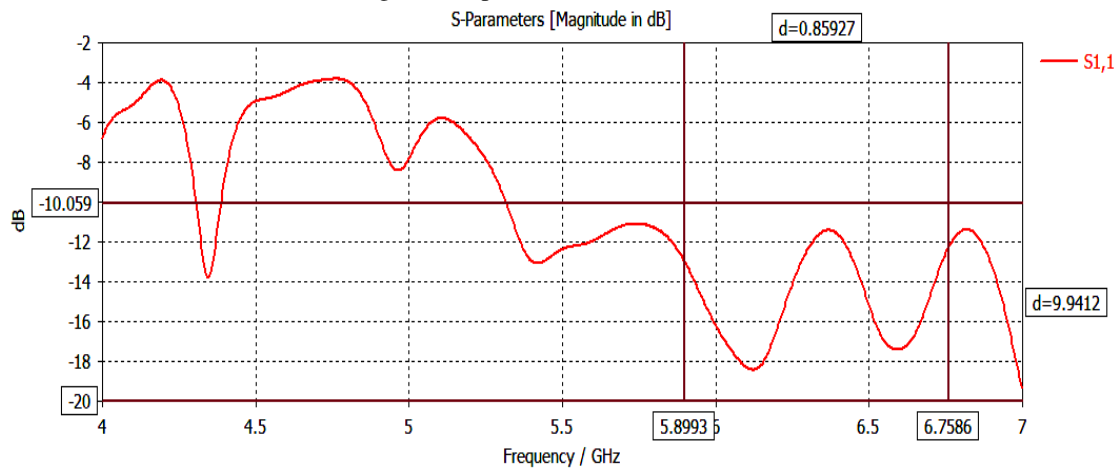


Figure 8: Bandwidth calculation

The transmission capacity of proposed antenna when DGS is 859MHz (6.7586GHz-5.8993GHz) for all available bands.

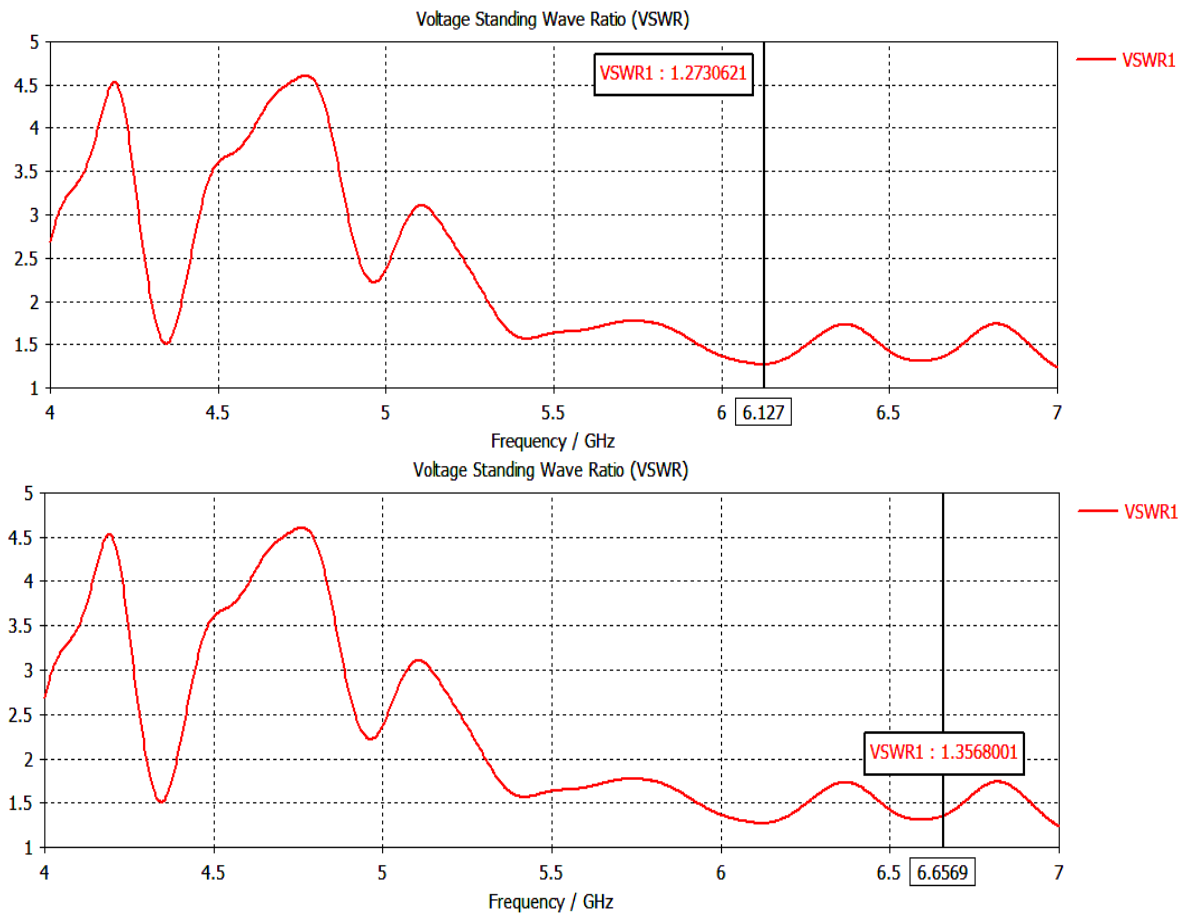


Figure 9: Voltage Standing Wave Ratios

VSWR must lie in the range of 1-2, which has been achieved for the frequencies 6.127GHz and 6.656GHz. The value for VSWR is 1.27 and 1.35 respectively.

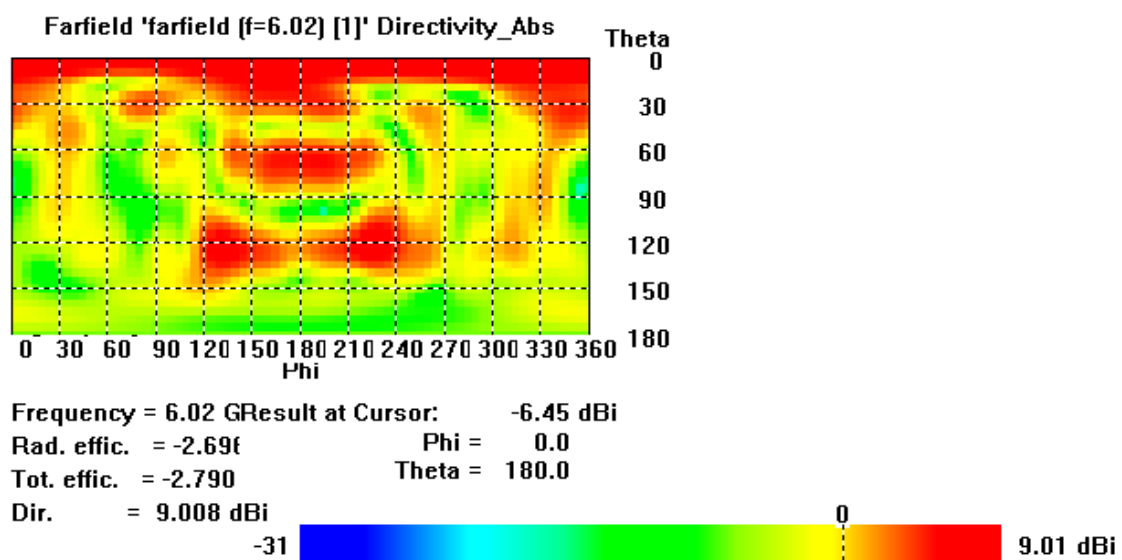


Figure 10: Far field directivity in 2 dimensional scales

Table 1: Design parameters for proposed frequency

Frequency(f_r)	4-7 GHz
Dielectric constant(ϵ_r)	4.4 / FR4
Metal Height	0.035mm
Substrate Height(h)	1.57 mm
Line Impedance	50 Ω
Antenna Length	35mm
Antenna Width	35mm
Tangent Loss	0.06

Table 2: Result Comparison

Sr No.	Parameter	Previous work	Proposed work (Finite Ground)	Proposed work (Defected Ground)
1	-35 dB	-41.959db	-18.417db.	-35 dB
2	310 MHz	536 MHz	859 MHz	310 MHz
3	1.086	1.016	1.273	1.086
4	5.5 GHz	5.998GHz	6.1229GHz	5.5 GHz
5	13.7 dB	17.8 dBi	9.01dBi	13.7 dB

IV. CONCLUSION

Array Based Microstrip patch antenna with DGS is proposed for LTE Application. There are many array combinations in previous designs, most of the MIMO-Array pattern. Array based microstrip patch antenna are proposed for future wireless communication by many authors. In this paper 4X4 microstrip patch array antenna is planed and implement using CST software. Simulated results demonstrate that the frequency bandwidth covers LTE band (4-7) GHz, at resonant frequencies 6.12GHz and 5.5GHz respectively for finite and defected ground structure and VSWR under 2, and S11 not exactly -10 dB. In above clarified working band it demonstrates great impedance coordinatng and bidirectional radiation designs. Therefore, it is seen that DGS gives better bandwidth than finite structure.

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