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Dual Band Microstrip Patch Antenna For Wireless Communication Applications

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ABSTRACT

The proposed work investigates the design of dual band microstrip patch antenna for the wireless communication applications. The performance of the proposed antenna is planned to design on a low-cost FR-4substrate material. The designed antenna is expected to be operating at dual frequency bands. The antenna parameters like resonance frequency, return loss, bandwidth, gain and radiation patterns are going to be studied. Simulation and experimental results are going to be analyzed using the 3DEM Mentor Graphics simulation software. The proposed antenna expected to be suitable element for wireless communication applications.

Keywords: Microstrip, Wireless Communication, Dual Band.

I.INTRODUCTION

1.1 BACKGROUND AND MOTIVATION

The antennas are going to be the basic components required for working of every wireless communication system. The transfer and receiving of electromagnetic waves with different frequencies in communication systems will be carried out by using the antennas. The large amounts of antennas are acts like resonant devices that are going to operate more effectively over a frequency band which is narrow in characteristics. Wireless communication systems over a period of time became very compact. As a result, the antennas which are used should be lighter and smaller in size. In reality, microstrip antennas meet these specifications. Furthermore, they give advantages such as ease of manufacturing, lower cost and incorporating into arrays. Because of above characteristics microstrip antennas became best solution for wireless applications.

However, the MSA have certain limitations like narrow impedance BW, low power handling capacity, poor radiation efficiency, losses due surface wave stimulation, etc. These disadvantages limit the operation of the ordinary configuration of patch antenna. For instance, it is required for MSA to offer gain that is not related to its dimensions. Similarly to this, a higher bandwidth is required than the element could provide since the element works like resonating cavity. Furthermore, the fast expansion of mobile telephony and WLANs necessitates use of equipment that can operate in many bands. Printed antennas were designed with the objective of becoming adaptable to different communication protocols.

One of the most additional options for several systems that require a radiating element is the MSA and it is sometimes termed as individual of exciting breakthroughs in the past of electromagnetics and antenna. Modern digital WCS and radar communication applications require low profile antennas with sufficient large bandwidth, multi-frequency operation, and low cross polarisation. Traditional antennas such as horn, loop, dipole, and helix are the most frequently used antennas. The above antennas are also physically large in size, making it difficult for them to be used or adapted in the wireless communication field.

1.2 PROBLEM STATEMENT

This research work has been taken up with the aim of designing dual band microstrip patch antennas for wireless communication applications. From literature survey it is found that number of attempts has been made to increase various parameters of microstrip patch antenna for wireless applications. Hence it is planned to improve the return loss, gain, bandwidth and radiation patterns by designing microstrip patch antenna for dual band.

1.3 OBJECTIVES

i. To design dual band microstrip patch antenna using combined properties of compactness and improved gain.
ii. To design dual band microstrip patch antenna with enhanced bandwidth and better radiation patterns.
iii. Simulate microstrip patch antenna using 3DEM of mentor graphics Software.
iv. Using microstrip patch antennas for various wireless communication applications.

II. LITERATURE SURVEY

P. Gupta, [1] described **evolvement of mobile generations: 1G To 5G**. In the proposed work gives an over view of evolution of Mobile Generations and also the framework of 4G technology that will provide access to wide range of telecommunication services, including advanced in mobile services, supported by mobile and fixed networks, which are increasingly packet based, along with a support for low to high mobility applications and wide range of data rates, in accordance with service demands in multiuser environment.

Jeffrey G. Andrews et al., [2] presented **What will 5G be?** This proposed work discusses all of these topics, identifying key challenges for future research and preliminary 5G standardization activities, while providing a comprehensive overview of the current literature, and in particular of the papers appearing in this special issue. As this article has highlighted, it is a long road ahead to truly disruptive 5G networks. Many technical challenges remain spanning all layers of the protocol stack and their implementation, as well as many intersections with regulatory, policy, and business considerations.

N. Ojaroudiparchin et al., [3] described **A 28 GHz FR-4 Compatible Phased Array Antenna for 5G Mobile Phone Applications**. In this proposed work, a new air-filled slot-loop phased array antenna aiming for 5G mobile communications is presented. The antenna is designed on a low-cost substrate (FR-4) to operate at 28 GHz. Ten elements of slot-loop antenna elements have been used for form a uniform linear array on the top region of the cellular handset PCB. The proposed antenna has good performance in terms of S-parameter, gain, efficiency, and beam steering characteristics.

G. Gampala et al., [4] presented **Design of Millimeter Wave Antenna Arrays for 5G Cellular Applications using FEKO.** This proposed work discusses some of these futuristic technologies that are laying the foundation for the 5G standards, highlighting the concept of massive MIMO that employs antenna arrays and beamforming techniques to address the high data rate demands.

S. X. Ta et al.,[5] demonstrated **Broadband Printed-Dipole Antenna and Its Arrays for 5G Applications.** In this proposed work, To realize a wide frequency range of operation, the proposed antenna is fed by an integrated balun, which consists of a folded microstrip line and a rectangular slot. For compactness, the printed dipole is angled at 45º. The single element antenna yields a $|S11| < -10$-dB bandwidth of 36.2% (26.5–38.2 GHz) and a gain of 4.5–5.8 dBi. We insert a stub between two printed-dipole antennas and obtain a low mutual coupling of < -20 dB for a 4.8-mm center-to-center spacing (0.42–0.61λ at 26–38 GHz). This proposed work demonstrate the usefulness of this antenna as a beamforming radiator by configuring 8-element linear arrays. Due to the presence of the stubs, the arrays resulted in a wider scanning angle, a higher gain, and a lower side-lobe level in the low-frequency region.

A. F. Kaeib et al., [6] presented **Design and Analysis of a Slotted Microstrip Antenna for 5G Communication Networks at 28 GHz.** In this proposed work, a conventional rectangular microstrip antenna is presented and modified by inserting slots in the radiator to propose a compact slotted microstrip antenna with simple configuration operating at 28 GHz for 5G applications; Based on the simulation results, it can be concluded that, the proposed slotted antenna has a compact size with a simple configuration, and it operated at 28 GHz, which covers (26.81GHz - 29.29 GHz) band with radiation efficiency of 86.73%, and high level of impedance matching, where VSWR is less than 2 and the return loss is better than -10 dB .

P. M. Teresa et al., [7] suggested **Compact Slotted Microstrip Antenna for 5G Applications Operating at 28 GHz.**The proposed antennas showcased improved performance with variations in slots. By adding more number of slots the effective area gets decreased and the bandwidth enhanced. The enhancement in bandwidth increases the user occupancy which is necessary for 5Gmobile communication. The overall dimension of the proposed antenna is 7mm×7mm×0.8 mm. The return loss is −27.79 dB with VSWR 1.08 which is less than2. The proposed antenna-III provides excellent performance over the existing antennas with better gain and band width characteristics. The size is compact and can be operated with good performance for 5G mobile communication system. Due to its compactness highly sensitive setup is required for fabrication as well as testing. In future, the designed 5G antenna can be fabricated and tested.

R. Przesmycki et al., [8] presented **Broadband Microstrip Antenna For 5G Wireless Systems Operating at 28 GHZ**. In this proposed work A rectangular microstrip antenna has been proposed for 5G applications in response to the growing demand for mobile data and mobile devices. This antenna has a resonance frequency of 28.00 GHz, for which the reflectance is equal to −22.50 dB. The proposed antenna has a radiation efficiency of 80.18% and the antenna gain for the resonance frequency is 5.06 dB. The results also show that its bandwidth is 5.57 GHz (relative operational band 19.89%), which is a very good result, much greater than results achieved in other published works, such as [15,16], where the operating bandwidth of the proposed antennas is around 1 or 2 GHz [18,19,20]. The proposed antenna would be a good option for 5G mobile communication, as it offers the high throughput required. The antenna is very compact and lightweight, which makes it suitable for devices where space is a major limitation.

Suneel Kumar et al. [9] presented **Low-Cost and Dual band Microstrip Patch Antenna for Ku and K Band Applications**. This proposed work demonstrated the capabilities of a copper-conducting dual band antenna. These parameters have also been created and tested using simulations at operating frequencies of 13 and 22 GHz. Maximum gain values at 13 and 22 GHz are 4.81 dB and 4.82 dB, respectively. Ku and K band applications are well suited for the suggested antenna.

T.Kiran, N.Mounisha et al.,[10] described **Design of Microstrip Patch Antenna for 5g Applications.** This proposed work is embedded with microstrip patch antenna that is constructed for future 5G wireless communications. The antenna has a compressed structure of 11mm x 8 mm x 0.5mm, including the ground plane. This antenna is designed using Rogers RT/duroid 5880 substrate used as dielectric material with a miniaturized size of 4.4mm x 3.3mm. Its dielectric constant is 2.2 and has thickness of 0.5 mm. This microstrip patch antenna resonates at frequencies of 28 GHz and 50 GHz. The antenna is simulated by using high frequency structure simulator. The antenna provides a gain of 2.6dB.

Jatin Kumar Singh et al.,[11] presented **Design and Analysis of Tiny Microstrip Patch Antenna for 5G Applications**. The microstrip antennas are employed in this study for public safety communications because of its mobility and light weight. The antenna is intended for use as a wearable device. The microstrip antenna was modeled and simulated using CST Microwave Studio 2019. As a dielectric, a ROGERS RT5880(LOSSY) substrate will be employed. The simulated results match the intended parameters exactly. The antenna's size has been reduced to make it more compact and adaptable. The antenna's dimensions and overall thickness are 5.5 X 5.5 mm and 0.017mm, respectively. The resonance frequency is 33.4 GHz, and the effective bandwidth for these results is 28 GHz to 35 GHz.

Sachin, B.M. et al.,[12] suggested **Design and Simulation of Dual Polarized Patch Antenna.A single layer dual-polarized**. microstrip patch antenna with dual port is designed, simulated and analyzed. The two ports are provided with a 1800 phase shift and designed to operate in the C-band with a solution frequency at 4GHz. The edges of the patch are etched which helps to improve the polarization of the designed antenna. The inset feed is the feeding technique used for the design of the dual-polarized antenna which provides a gain of about 8.5dB. This paper describes the parameters of the dual-polarized patch antenna like VSWR, Radiation Pattern, Axial Ratio and Return Loss are simulated and results are recorded. The proposed antenna works for the single narrow band frequency having a return loss lesser than -10dB and finds its application in satellite communications and weather RADAR.

III. EXISTING METHODOLOGY

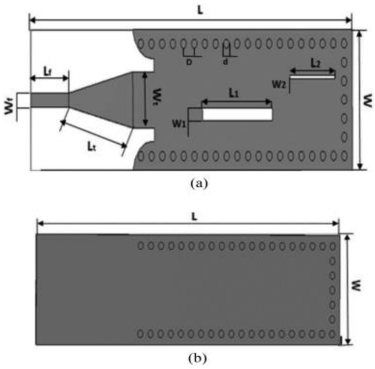

Fig.1.Structure of the dual-band slotted SIW single element antenna (a) view from the top and (b) view from the bottom.

Priyanka Kumawat et al., [13] presented Design of 28/38 GHz Dual-Band SIW Slot antenna for 5G Applications. This work shows a dual-band linearly polarized substrate integrated waveguide (SIW) antenna with two slots on the substrate for future 5G communication. In this proposed work, a dual-band single element slotted SIW antenna has been illustrated. The antenna comprises two slots and impedance matching gaps between the SIW structure and transition line to enhance the gain, bandwidth, and impedance. The proposed antenna working at28 GHz frequency band (27.448-28.475) GHz and at 38 GHz frequency band (37.88-38.32) GHz and offer adequate radiation pattern, impedance bandwidth, and gain. The single element realized 7.2 dBi and 11.2 dBi gain for the lower (28 GHz) and upper (38 GHz) band individually. The proposed SIW antenna is recommended for fifth generation applications because of its good performance.

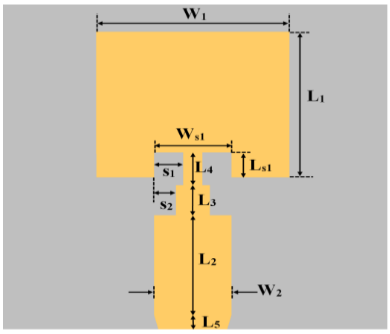

Fig. 2.Geometry of the patch antennas.

D. Alvarez Outerelo et al., [14] described Microstrip Antenna for 5G Broadband Communications: Overview of Design Issues. In this proposed work present two practical implementation cases of single patch antennas at 28GHz and 60GHz. This work describe the design challenge of conciliating the antenna performance specifications and fabrication restrictions. Over this basic element of an array antenna This work discuss the influence of three different categories of design issues. i)Inaccurate value of relative dielectric permittivity εr: ii)Connector - feed line soldering iii)Fabrication mechanical inaccuracies and errors.

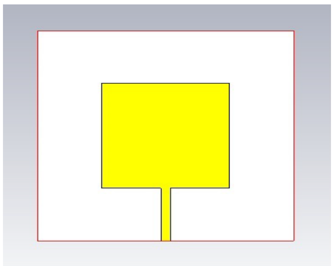

Fig.3 Geometry of the of the proposed patch antenna

Y. Jandi et al., [15] presented Design of a compact Dual bands patch antenna for 5G Applications. This proposed work presents the design of a compact size dual bands patch antenna for the next generation5G devices. The proposed compact size antenna has a compact structure of 19 × 19 × 0.787mm3 including the ground plane. The proposed antenna operates at 10.15 GHz and 28 GHz which are two of the candidate frequencies for the 5G mobile communications. the proposed design provides a gain of 5.51 dB at 10.15 GHz and 8.03 dB at 28 GHz and a directional the radiation pattern. The antenna was designed on Rogers5880 substrate with a thickness of 0.787mm. In this proposed work geometry of the antenna and various parameters such as return loss plot, gain plot, radiation pattern plot and VSWR plot are presented and discussed.

IV. PROPOSED METHODOLOGY

4.1 INTRODUCTION

In this chapter, design considerations and the proposed designs of MSA are described. The proposed designs are simulated using Method of Moment based electromagnetic software Hyperlynx 3DEM software V15.3 (formerly called IE3D).

4.2 DESIGN SPECIFICATIONS

Designer needs to consider three vital parameters to design microstrip patch antenna of any shape, which are as follows

- **Dielectric constant of the substrate (ε_r):** The substrate selected for proposed design is a less expensive glass epoxy commonly known as FR4 where “FR” stands for flame retardant. The dielectric constant of the glass epoxy substrate is 4.4, and its loss tangent is 0.0245.
- **Height of substrate (h):** It is very much essential to make sure that the patch antenna is not bulky in order to use it in wireless applications. Usually, the thickness or height of the dielectric substrate is preferable very thin i.e., 1.6 mm.
- **Frequency of operation (f_r):** FR4 is a lossy substrate and exhibits poor performance with the increase in frequency and certainly not a good choice at higher frequencies. However, for research purpose, as it is cheap and easily available, can be used for prototype testing presenting new results/ideas.

4.3 DESIGN OF SINGLE MSA

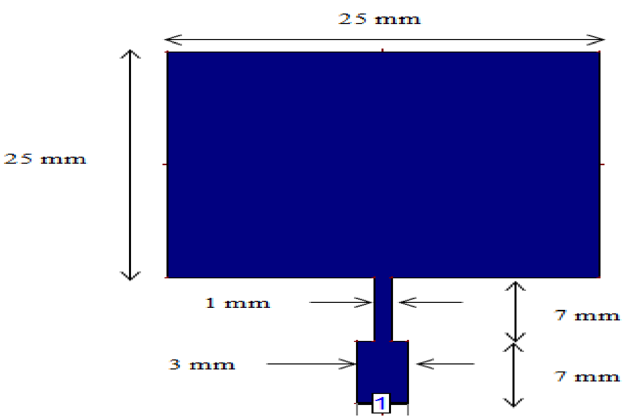

Fig. 4: Geometry of proposed MSA

The above fig.4 represents geometry of proposed single MSA. The length to be 25 mm and width to be 25 mm respectively. The microstripline feeding technique is used with two feed lines of 7 mm with widths of 1 mm and 3 mm respectively.

4.4 DESIGN OF 1x2 ARRAY

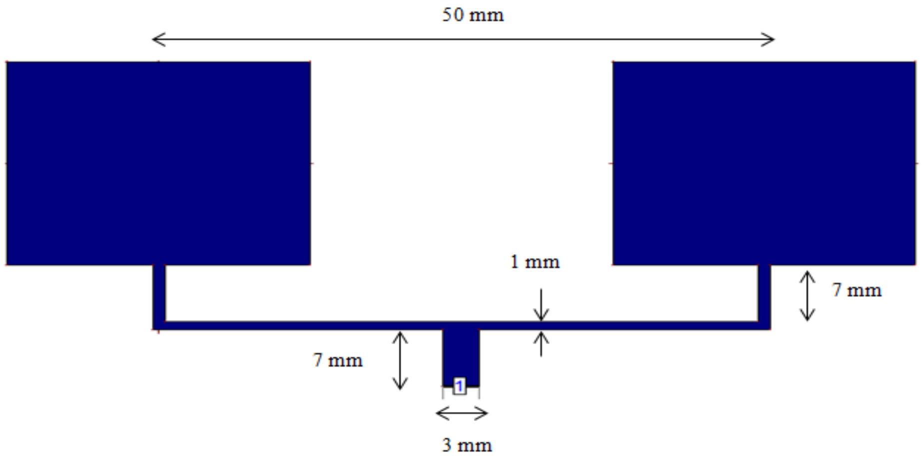

Fig. 5: Geometry of proposed 1x2 Array

The above fig.5 represents geometry of proposed 1x2 array. The inter element distance between two patches to be 50 mm. The microstripline feeding technique is used with width of 1 mm and length 7 mm. Both are joined at final feeding location with length of 7 mm and width of 3 mm respectively.

V. RESULT AND DISCUSSIONS

This chapter discusses the simulation results of the single patch and 1x2 array.
The resonance frequency, return loss, bandwidth, gain and radiation patterns are studied.

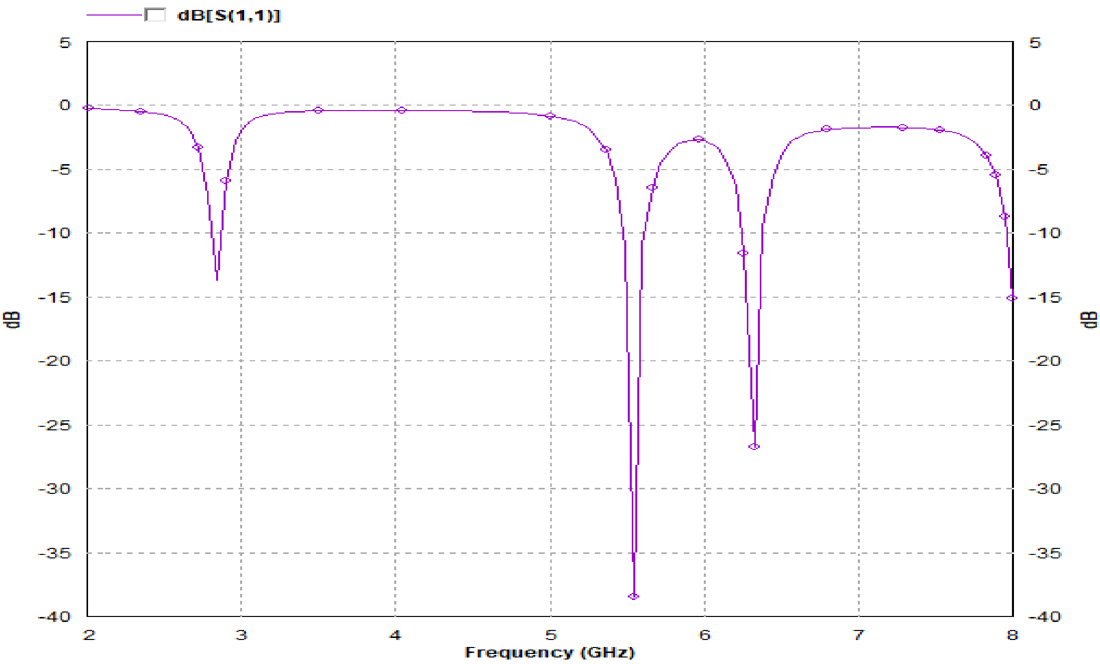

Fig.6 Simulated resonance frequency, return loss and bandwidth

The above fig.6 shows simulation results of single MSA. The antenna is resonating at a frequency of 2.82 GHz, 5.5 GHz and 6.32 GHz Respectively. The return losses obtained are -12.7 dB, -24.3 dB and

-26.6 dB respectively. The bandwidths obtained are 6 MHz, 146 MHz and 137 MHz Respectively.

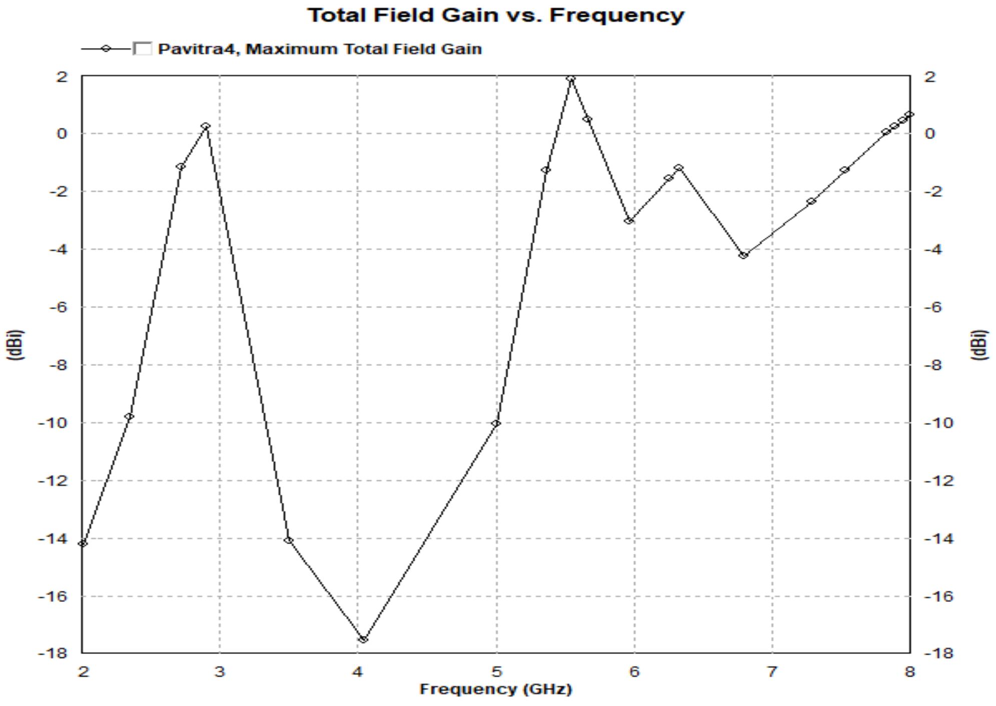

Fig.7 Simulated resonance frequency v/s gain

The above fig.7 shows simulation results of single MSA. The antenna is resonating at a frequency of 5.5 GHz, the gain obtained is 1.52 dB.

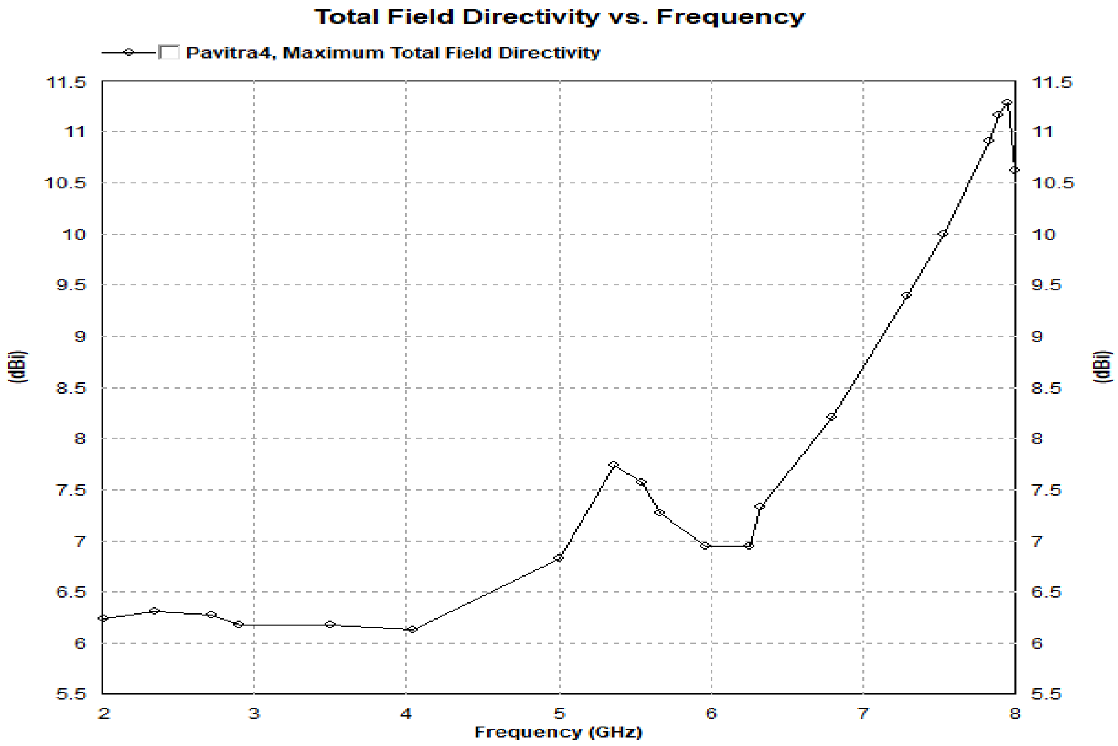

Fig.8 Simulated resonance directivity v/s gain

The above fig.8 shows simulation results of single MSA. The antenna is resonating at a frequency of 2.82 GHz, 5.5 GHz and 6.32 GHz Respectively. At 2.82 GHz the directivity obtained is 6.3 dB, at 5.5 GHz the directivity obtained is 7.7 dB and at 6.32 GHz the directivity obtained is 6.9 dB. The maximum value of directivity obtained is 11.4 dB.

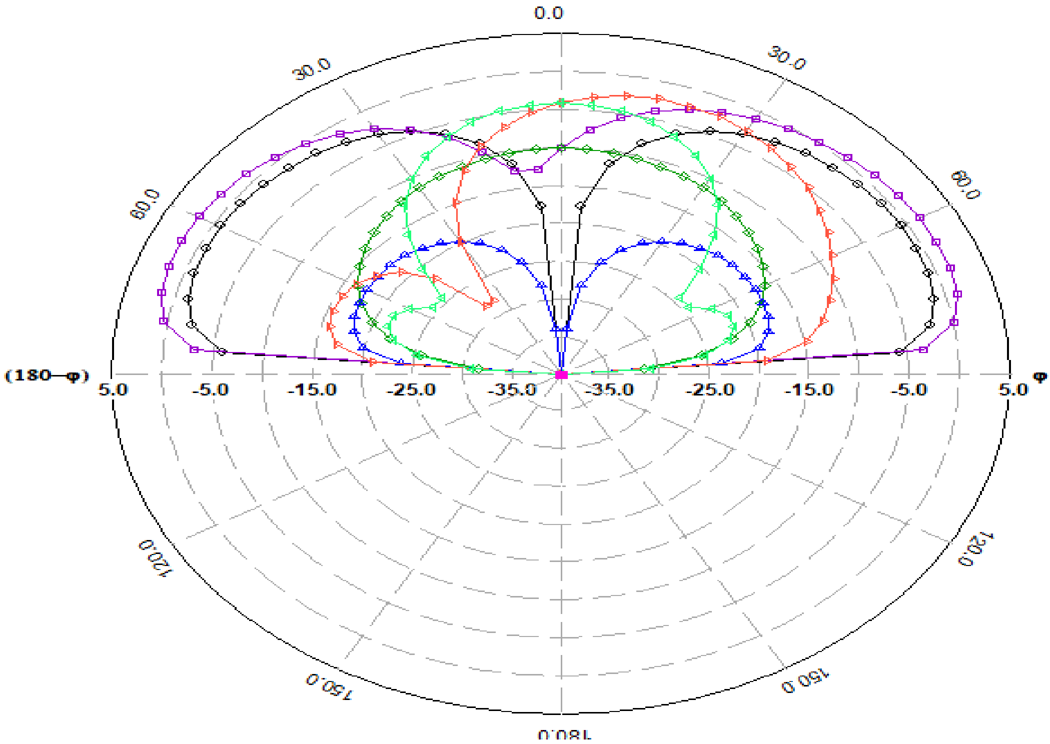

Fig.9Simulated radiation patterns

The above fig.9 shows simulation results of single MSA. The nature of radiation patterns shows that there is a well directed main lobe which is uniformly distributed.

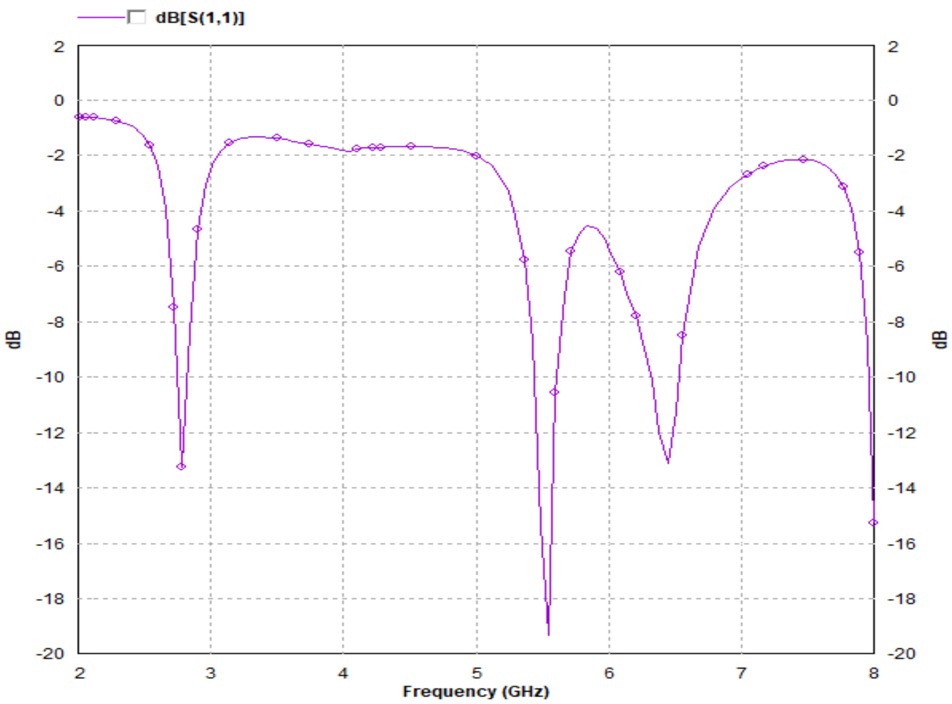

Fig.10 Simulated resonance frequency, return loss and bandwidth

The above fig. 10shows simulation results of 1x2 Array. The antenna is resonating at a frequency of 2.80 GHz, 5.5 GHz and 6.4 GHz Respectively. The return losses obtained are -10.63 dB, -18.13 dB and

-13.01 dB respectively. The bandwidths obtained are 8 MHz, 181 MHz and 209 MHz Respectively.

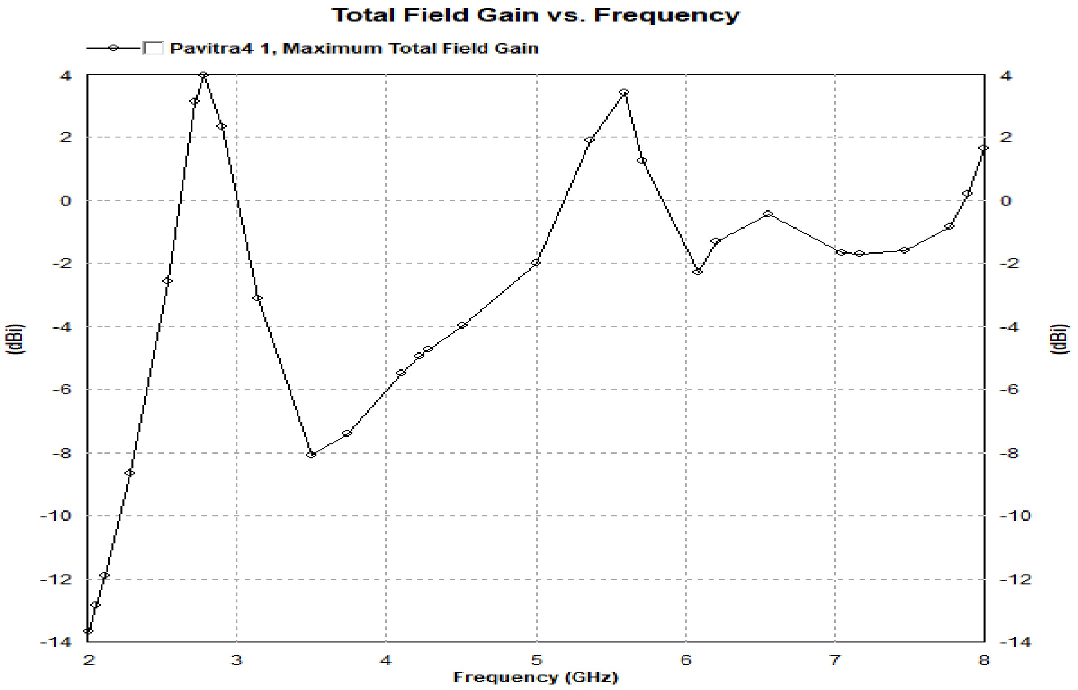

Fig.11Simulated resonance frequency v/s Gain

The above fig.11 shows simulation results of 1x2 Array. The antenna is resonating at a frequency of 2.80GHZ with Gain of 3.9dB and at 5.5 GHz, the Gain obtained is 3.3 dB respectively.

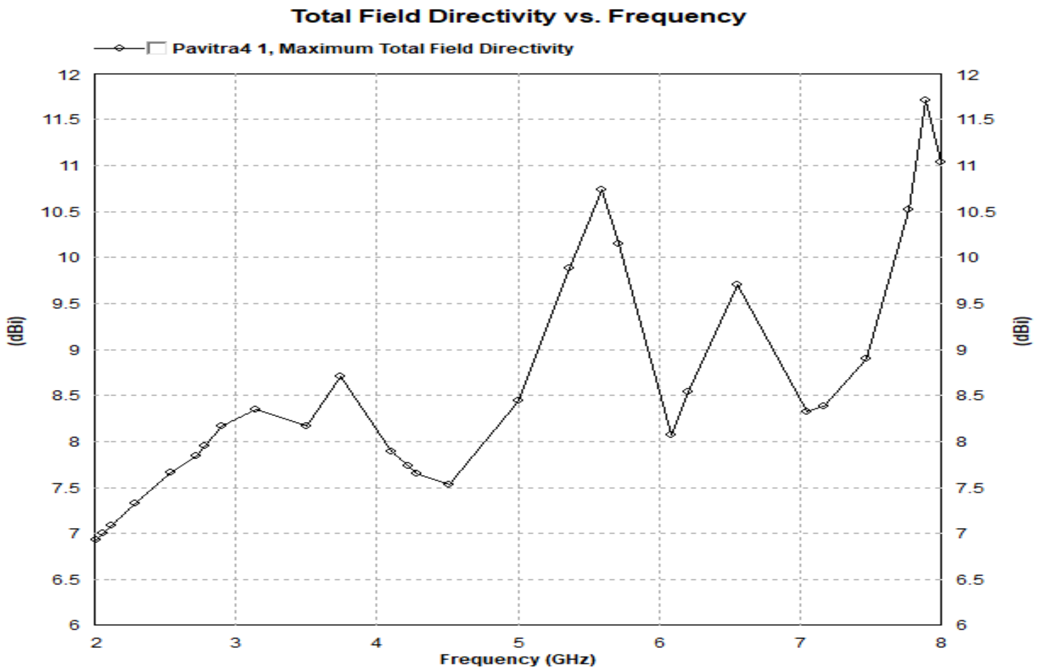

Fig.12 Simulated resonance directivity v/s gain

The above fig.12 shows simulation results of 1x2 Array. The antenna is resonating at a frequency of 2.82 GHz, 5.5 GHz and 6.32 GHz Respectively. At 2.82 GHz the directivity obtained is 7.9 dB, at 5.5 GHz the directivity obtained is 10.8 dB and at 6.32 GHz the directivity obtained is 8.5 dB . The maximum value of directivity obtained is 11.7dB.

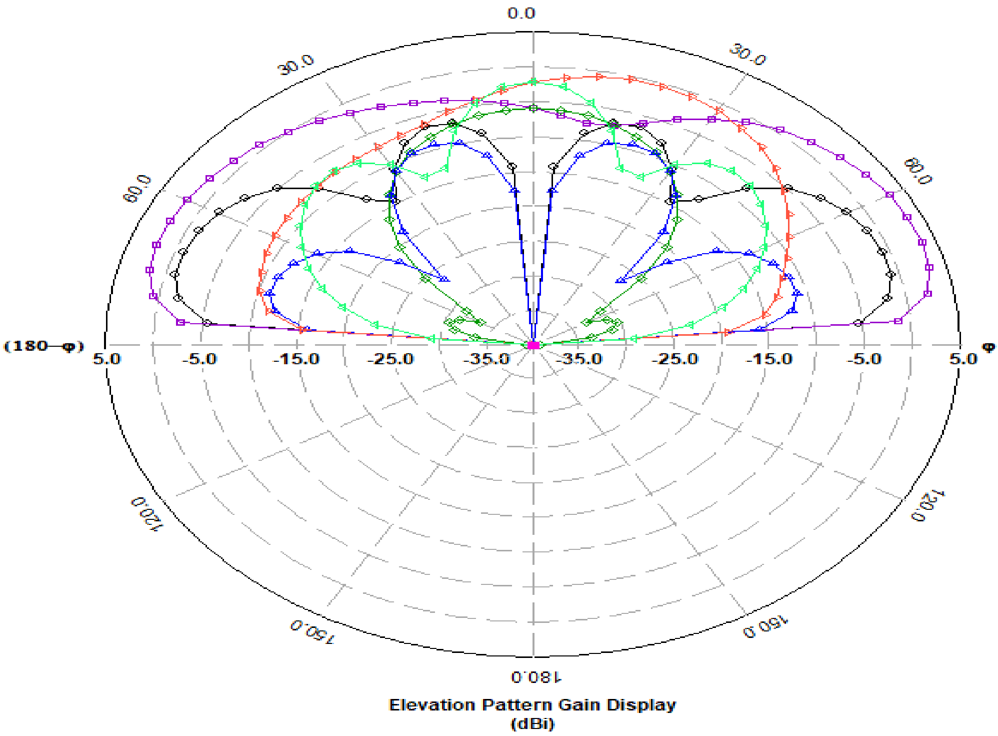

Fig.13 Simulated radiation patterns

The above fig.13 shows simulation results of 1x2 Array. The nature of radiation patterns shows that there is a well directed main lobe which is uniformly distributed with minor side lobes.

The comparisons of simulated results of single and 1x2 array are studied in table I.

Table 1 comparisons of simulated results of single and 1x2 array

Sl .No	**Antenna configuration**	**Frequency (GHz)**	**Return Loss (dB)**	**Bandwidth (MHz)**	**Gain (dB)**	**Directivity (dB)**
1	Single Patch	2.82 GHz , 5.5 GHz and 6.32 GHz	-12.7 dB, 24.3 dB and -26.6 dB	6 MHz, 146 MHz and 137 MHz	1.52 dB	6.3 dB ,7.7 dB and 6.9 dB
2	1x2 Array	2.80 GHz ,5.5 GHz and 6.4 GHz	10.63 dB, -18.13 dB and -13.01 dB	8MHz ,181 MHz and 209 MHz	3.9 dB, 3.3 dB	7.9 dB ,10.8 dB and 8.5 dB

VI. CONCLUSION AND FUTURE SCOPE

The proposed dual band microstrip patch antenna was designed and simulated using FR-4 substrate to cater to modern wireless communication needs. Both single patch and 1×2 array configurations were analyzed, and results indicate that the antenna achieves dual-band operation with desirable parameters such as low return loss, improved bandwidth, acceptable gain, and well-directed radiation patterns. Simulation and experimental results are going to be analyzed using the 3DEM Mentor Graphics simulation software. The 1×2 array configuration demonstrated superior gain and directivity over the single patch, making it more suitable for high-performance communication systems. The proposed antenna expected to be suitable element for wireless communication applications The design also offers advantages such as compact size, ease of fabrication, and cost-effectiveness.

Future Scope:
The work can be extended in the following directions:

1. Fabrication and Testing: Fabricate the proposed antenna and validate the simulated results through experimental measurements.
2. Material Optimization: Explore advanced low-loss substrates like Rogers RT/duroid to improve efficiency at higher frequencies.
3. Multiband Design: Extend the design to support more than two frequency bands for compatibility with multiple wireless standards.
4. Miniaturization: Apply techniques such as slotting, meandering, or metamaterials to further reduce the antenna size while maintaining performance.
5. Integration: Integrate the antenna into compact wireless devices, IoT modules, or MIMO systems for real-world applications.

With these improvements, the proposed antenna can evolve into a versatile and high-performance solution for next-generation wireless communication systems.

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