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HIGH GAIN MICROSTRIP PATCH ANTENNA FOR 5G COMMUNICATION AT 4 to 6 GHz

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Abstract* - The design of a microstrip patch antenna for fifth-generation (5G) wireless communications operating at sub-6 GHz is presented in this study. A rectangular microstrip patch using the air gap technique makes up the design. Copper makes up the ground plane of the suggested antenna. To further improve the performance of the antenna, the ground plane is linked to the antenna patch. The proposed antenna uses the inset feeding line approach and is built on a FR-4 epoxy substrate. The HFSS software is used for design and simulation. With a maximum gain of 4.42, the antenna patch measures 10.2 x 26 x 1.6 mm and the parallel patch is 12.2 x 26 x 1.6 mm. The proposed antenna spans the 4.8 GHz - 5 GHz range for sub-6 GHz 5G communications and operates for a bandwidth from 4.0 GHz to 6.5 GHz.

I. INTRODUCTION

Planar resonant cavities called microstrip antennas radiate and leak energy from their edges. In order to create low-cost, repeatable antennas with a low profile, printed circuit techniques can be employed to etch the antennas onto soft substrates. The antennas made on flexible substrates can tolerate extreme shock and vibration. In order to avoid the expense of substrates and etching, manufacturers of mobile communication base stations frequently produce these antennas directly in sheet metal and mount them on dielectric poles or foam in a number of ways. As a result, the issue of surface wave radiation that might occur when a thick dielectric substrate is employed to increase bandwidth is also resolved.

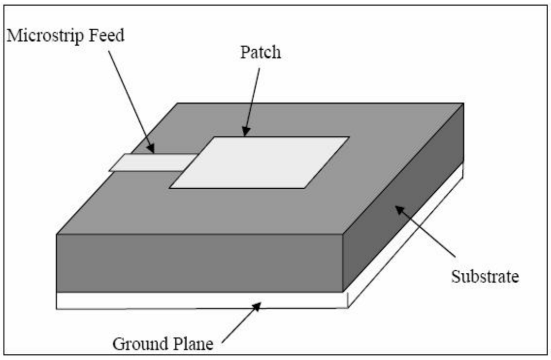

Figure 1.1 Microstrip Line Feed

II. RELATED WORK

Mohammed Faisal [1] At 28GHz, a single band microstrip square patch antenna is suggested. Due to their inexpensive manufacturing costs, light weight, and ability to operate at microwave frequencies, patch antennas are very effective and frequently used in wireless communication. However, they offer low efficiency, low gain, and other drawbacks. Due to their millimeter-wavelength antennas, future 5G wireless communication will require strong gain and good protection from route loss. The primary characteristics of this suggested antenna are its extremely low return loss (S11), high gain, improved efficiency, and greater bandwidth, which are 57 dB, 10.3 dB, 97%, and 4.3GHz, respectively. These characteristics make it suitable for 5G wireless communication. At an operational frequency of 28 GHz, the suggested square patch antenna is designed and modelled using CST Microwave Studio. The use of an air substrate increases the antenna's gain. With the suggested antenna design, the antenna can deliver a high radiation power for 5G communication with a very low return loss of 57 dB.

Bo He. [2] In this work, they suggested High Gain Lens Antenna For 5G Communication. For use with fifth generation (5G) communications systems, a high-gain lens antenna is created. The structure of the suggested design consists of a multi-layer dielectric lens and a coaxially fed patch antenna. The patch antenna's substrate was created by RT 5880, and its operating frequency is 17.5 GHz. CST Microwave Studio simulates the antenna structure. The simulation results demonstrate that due to the exceptional characteristics of the dielectric lens, the peak gain of the lens antenna is significantly increased from 8.18 dB to 16.3 dB, and also the primary beam width is significantly decreased by 50 degrees.

Sun Houjum. [3] For 5G communication, they create single element patch antenna. The suggested antenna in this study has overall dimensions of 25 x 19 x 0.5 mm, a relative permittivity of 2.2, and a loss tangent value of 0.0009. It is designed on a small Rogers Substrate Rt-5880. Without using any complicated gain-achieving techniques like EBG, CRR and SRR, linked Split rings, or metamaterial plates, the suggested device offers a high gain of 7.88 dB at 28 GHz and is more than 92% efficient. The suggested antenna's impedance bandwidth is between 27.67 and 28.118 GHz. where 10 db |S11|. Radiation patterns simulation results have directionality. One of the distinctive characteristics of the proposed antenna is its multi-beam directional emission pattern. . a huge profit By lining up the planner array with the linear array, ultra-wideband can be achieved. Utilising commercial 3D full-wave software, CST Microwave Studio 2018, the suggested antenna was developed and optimised. favourable gains support the antenna's ease of viability for 5G MIMIO applications The suggested design is regarded as a great option for 5G millimetre Wave communication because of its straightforward design structure, ease of production, and inexpensive cost.

Liton Chandra Paul. [4] For high-speed fifth generation (5G) communication applications, the researchers in this study decided to present a circular-shaped microstrip line-fed miniaturised patch antenna. The 3D electromagnetic (EM) simulation programme from CST Studio Suite is used to create and analyse the antenna prototype. The low-cost, widely accessible substrate material called FR4 with a dielectric constant of 4.3 is used to create the prototype. The proposed antenna has an optimised size of 18 x 17 x 1.605 mm3. The proposed antenna has a patch with a circular form, a partial ground plane, and a microstrip fed line with line stripes. Under a -10-dB scale, the developed antenna covers the upper 5G frequency spectrum, which spans from 24 GHz to 31 GHz. The efficiency attained is around 60%, and a maximum gain of 5 dB is realised. The designed antenna is put out as a potential contender for more advanced 5G applications.

S A Gaid [5] In this study, a rectangular microstrip patch antenna for 5G high-speed data transmission in the mm-wave band of frequencies between 75 and 110 GHz (Wband) was developed. A single element microstrip antenna with an overall dimension of 2.02 x 2.328 x 0.149 mm3 is the idea. The 1.1483 x 1.429 mm2 radiating element is printed on a substrate material (RT/Duroid5880) with a 0.149 mm height. The rectangular radiating patch and the feeding microstrip line are matched using the inset feed technique. The antenna spans the frequency range from 81.3717 GHz to 84.4912 GHz and has a fractional bandwidth of 3.76%, or approximately 3.12 GHz. Additionally, the measured return loss, VSWR, gain, and directivity are, respectively, 55.7937 dB, 1.0033 dB, 7.9087 dB, and 7.8914 dB. The suggested antenna's suitability for 5G mm-wave applications is supported by its good impedance matching, bandwidth, radiation characteristics at the working band, compact size, and tiny dimensions.

Patrick McEvoy [6] This research presents a fifth generation (5G) communications millimeter wave grid array antenna. The 4040 mm2 nearly-rhombic Grid Array Antenna construction with 20 cells is modelled and constructed on a Rogers RT 5880 substrate with a 0.25 mm thickness. The grid array has a percentage bandwidth and gain of 5.41% and 16.5 dBi, respectively, and has |S11|-10dB for two frequency ranges in the upper 26 GHz millimeter wave spectrum. Using the same substrate and dimensions, the antenna is compared to a Microstrip Patch Array.

Menal Fegade. [7] The 5G Micro-Strip Patch Antennas with Defected Ground Structure on Ground Slots are the main topic of this article. Defected Ground Structure is defined as slots or faults that merge on the ground plane of microwave planar circuits. DGS is a very efficient All of the antenna's characteristics and performance are enhanced using partial deflected ground structure. To obtain high gain and larger bandwidth, DGS was used. The partial ground's v slot and the flawed ground structure were introduced in the suggested work. As a result, the antenna's return loss, bandwidth, VSWR, efficiency, and compactness will all be improved.

Mouaaz Nahas. [8] The usage of microstrip patch antennas in contemporary mobile communication technologies, particularly 5G, has received extensive research. Such antennas can be made to operate in the low, mid, and high bands of 5G networks, according to earlier research in the field. This research focuses on 5G mobile applications for high-band millimetre waves. The suggested microstrip patch antenna was specifically made to work at 26 and 28GHz, the first and most popular frequency bands for 5G. In this work, a single rectangular patch, which is frequently used in other 5G antennas, is combined with a variety of different slot shapes in order to improve the gain and other radiation properties of the antenna. The findings demonstrate that a very high gain can be obtained by putting two symmetric L-slots and a square slot in the middle. The CST Studio Suite simulator was used to simulate and optimise the slot size. The proposed antenna has superior gain and directivity, extremely good VSWR and efficiency, and a relatively big enough bandwidth at the two resonance frequencies taken into consideration, according to a comparative research that was also carried out.

Tiago E S Olivieira. [9] This research presents a high-gain wideband parasitic microstrip antenna for 26 GHz 5G and IoT applications. First, a single antenna targeting the 5G New Radio (NR) Frequency Range 2 (FR2) band n258 has been investigated, described, and optimised to operate at 26 GHz. This antenna is made up of a miniature parasitic patch antenna. The suggested antenna surrounds a core patch that is fed by a probe with eight parasitic microstrip patches arranged in a square pattern. The magnetic and electric field produced by the central active patch connects the patches acting as parasite elements. Simulations show that a single optimised array antenna with an effective gain of 14.4 dBi and a total bandwidth of 4.15 GHz (16.29%) after optimisation in CST MWS has a total dimension of 2424 mm2, which corresponds to 2.12.1 of the operating frequency.

N Ramli. [10] This project involves the creation of two antennas, one of which is a basic rectangular microstrip patch antenna and the other of which is a rectangular microstrip patch antenna that has been enhanced with an air gap approach. Due to the RT5880 substrate's low dielectric constant of 2.2 and low permittivity of 0.0009, both antennas were created utilising it. The proposed antennas were examined and modelled using Computer Simulation Technology (CST) software for WLAN application at the 2.4GHz frequency. A 3 mm air gap thickness was introduced between the radiating patch element and the ground layer to improve the antenna's gain performance. According to the simulation findings, the antenna's gain increased by 32.9% from 6.907 dB (for the basic antenna) to 9.179 dB (for the antenna with a 3 mm air gap) while the frequency was kept at 2.4 GHz. The gain increased 11.4% from 7.1 dB (basic antenna) to 7.91 dB (antenna with 3 mm air gap), according to the measurement data. The simulation results showed that the bandwidth was reduced from 111.07

MHz (for a simple antenna) to 72.873 MHz (for an antenna with a 3 mm air gap). To verify the performance of the antennas, two prototypes have been made. The reflection coefficient, S11, gain, and VSWR simulation and measurement results are shown.

III.DESIGN STEPS

In the design process using Ansys HFSS software for the microstrip antenna model, several steps were followed. Here's a detailed explanation of the design process considering the specific details provided:

Setting up the HFSS Simulation Environment: Launch Ansys HFSS software and create a new project. Define the project units, frequency range, and other simulation settings based on the requirements of the microstrip antenna design.

Step 1: Geometry Creation:

Create the microstrip antenna model within the HFSS software. Design the main patch element with appropriate dimensions and position it on the substrate. Introduce a parasitic element with an air gap of around 1mm to enhance the antenna's performance.

Step 2: Material Assignment:

Assign the dielectric properties to the substrate material used in the microstrip antenna design. Specify the dielectric constant and loss tangent to accurately represent the substrate's behavior.

Step 3: Simulation Setup:

Define the simulation setup parameters, including the frequency range of interest and the desired number of frequency points for analysis. Specify the excitation source and the feeding technique used in the microstrip antenna.

Step 4: Simulation and Analysis:

Run the simulation in Ansys HFSS to obtain the results. Analyze the return loss, which indicates the amount of power reflected from the antenna. In this case, the return loss value of -14 suggests that a significant portion of the incident power is absorbed by the antenna, resulting in efficient power transfer.

Step 5: Radiation Pattern Analysis**:**

Evaluate the radiation pattern of the microstrip antenna. The radiation pattern depicts the distribution of radiated power in various directions. Assess the shape, beam width, sidelobes, and other characteristics of the radiation pattern to ensure the desired performance.

Step 6: Antenna Gain Calculation**:**

Calculate the antenna gain, which represents the ability of the antenna to direct and concentrate the radiated power in a specific direction. In this case, the antenna gain value of around 4.9 indicates that the antenna is capable of focusing the radiated power efficiently.

Step 7: Fabrication of the Antenna:

Once the simulation results are satisfactory, proceed with fabricating the physical antenna based on the optimized design parameters. Follow standard fabrication techniques, such as photolithography or additive manufacturing, to create the microstrip antenna structure on the chosen substrate material.

Step 8: Physical Antenna Evaluation:

Evaluate the performance of the fabricated physical antenna. Measure the return loss, radiation pattern, and gain of the physical antenna using appropriate measurement equipment. Compare the measured results with the simulated data to validate the accuracy of the design and assess the performance of the fabricated antenna.

By following this design process using Ansys HFSS software, researchers were able to model, simulate, and optimize a microstrip antenna with a parasitic element and an air gap. The simulation results indicated a return loss of -14, suggesting efficient power absorption by the antenna. The radiation pattern analysis verified the desired radiation characteristics, and the calculated antenna gain of approximately 4.9 confirmed the ability to focus the radiated power effectively. Fabrication of the physical antenna allowed for further evaluation and validation of the design.

IV.SIMULATION AND RESULT

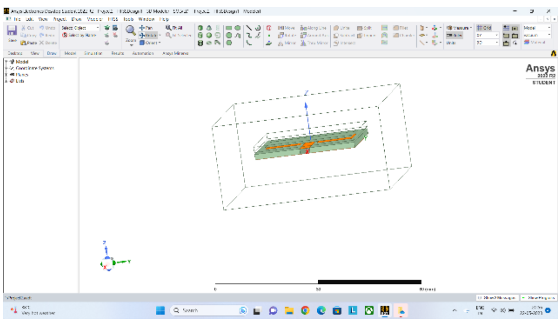

Figure 4.1: Antenna Design in HFSS

Table 4.1 Design Parameters of Antenna

Parameter	L	W	h	Ppatch(L)
Dimension(mm)	10.4	26	1.6	12.4

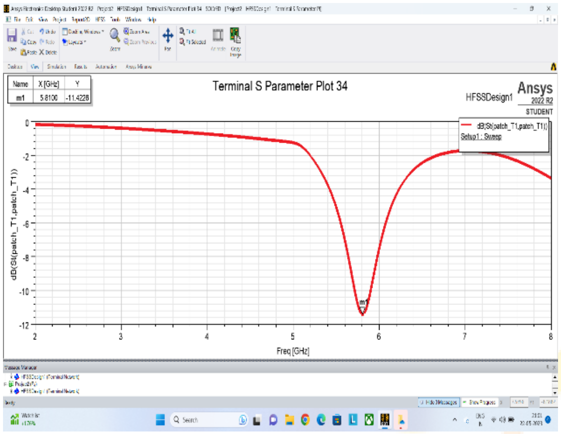

Figure 4.2: S Parameter Plot

The return loss of the simulated microstrip patch antenna is |S11|-10 dB, or -11.44 dB. Return loss is -11.422 on 5.81 GHz, the frequency. We're going to examine gain at this frequency.

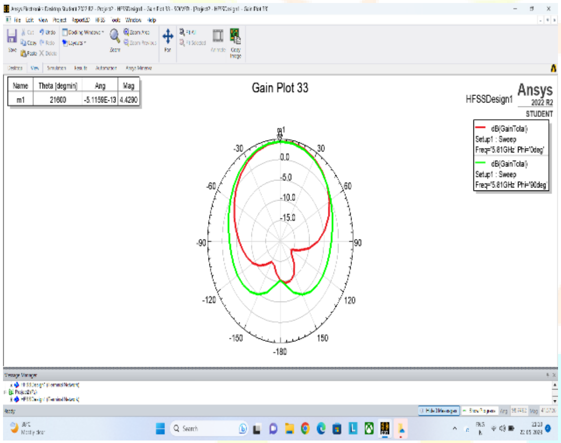

Figure 4.3: Gain Plot

Gain is 4.42 dB on 5.81 GHz frequency. By using air gap between the patch and parallel patch of 0.6 mm the gain is increased.

Table 4.2 Gain Increment

Technique	Gain(dB)	|S11|	Frequency(GHz)
Normal	1.6	-16.3	6
Miniaturization	2.9	-35.4	5.9
Air Gap	4.42	-11.4	5.81

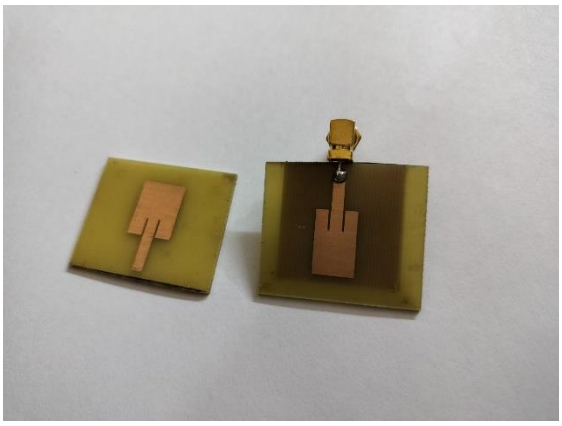

Figure 4.4 Fabricated Antenna

IV. CONCLUSION

"High Gain Microstrip antenna for 5G Communication" is a low-profile high gain antenna, which increases the range of for covering long distance communications. The advantage of this antenna is to provide an easy and cost-effective solution to increase microstrip antenna gain, without disrupting its planar structure. Thus, increasing the gain of the microstrip antenna will simply offer long distance communication using a very small antenna. We have increased the gain of antenna by using air gap technique. In this we made a parallel patch and the gap between the parallel patch is 0.6 mm. This increases our gain from 1.6 dB to 4.42 dB which is operating at 5.81 GHz frequency.

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