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A RECTANGULAR MICROSTRIP PATCH ANTENNA FOR 5G APPLICATIONS

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Abstract:This paper is to design and development of an Rectangular Microstrip Patch Antenna for 5G Applications. The transition from 1G mobile technology to 2G, 3G, and 4G is happeninggradually as a result of tremendous technological advancement and the enormous needfor data traffic. Fifth generation cellular (5G) technology, which virtually eliminates thedrawbacks of earlier technology that offers data speeds in Gigabits/sec (Gbps) and serves the quickly expanding class of low powerInternetofThings(IoT) applications.Afurtherexpanding areainmanyindustries is the integrationofRadioFrequencyIdentification(RFID)and5Gtechnologies.Itissimulated and can be designed by the High Frequency Structure Simulator (HFSS) tool. For5Gapplicationsoperatingat27GHz,amicrostriplinefedrectangularpatchantenna has beensuggested.Theefficiencyofthemicrostrippatchantennacanbeincreased than the existing method. The suggested antenna isa promising contender for 27 GHzmillimeterwave(mm-wave)applicationssinceithasacompactdimension(20x17x 1.575 mm^3), a wide bandwidth, good gain and directivity.

Keywords--- *RFID, IOT, HFSS tool etc.*

I. INTRODUCTION

Wireless communication technology is growing rapidly due to the advance in the number of users in rate of internet usage. The speculation of 1G, 2G, 3G and recently 4G LTE technologies one of the alarming factors that affect the today's wireless communication is lack of feasible frequency resources. So, to solve this problem, research began to start in 5G wireless communication at millimeter frequency band, which ranges between 20 GHz to 300 GHz. Mainly the frequency range used for 5G research are in range of 24 GHz to 60 GHz. Diverse fields have embraced the 5G technology with Internet of things. One of the goals of 5G technology is to connect millions of devices together. This 5G technology can be used in smart cities, smart transportation and robotics. The rapid decrease in size of mobile devices set in motion to develop miniature antennas that could fit in those devices without affecting the function.

This caused the rise of microstrip patch antennas in the 20^{th} century. Microstrip patch antenna consists of a thin metal foil mounted on a substrate, beneath the substrate there is a presence of ground. This microstrip patch antenna can be integrated very easily on the surface of PCB, which can be used in mobile devices as well. These antennas are used in microwave and millimeter frequency bands. A rectangular microstrip patch antenna conceived for 5G communication application, which is operating at a mm wave frequency of patcantenna has been accepted using the substrate Fr4 epoxy with a relative dielectric constant equal to ε_r=4.4 and height of substrate (h) =1.6 mm.

II. EXISTING METHOD

A rectangular microstrip patch antenna is a popular choice for 5G applications due to its compact size, ease of fabrication, and compatibility with integrated circuits. Several existing methods can be used to design and optimize a rectangular microstrip patch antenna for 5G. Here's a step-by-step approach:

Substrate Selection: Choose a substrate material with low dielectric constant (around 2-4) and low loss tangent to achieve better radiation efficiency and reduced signal attenuation. Common substrate materials include FR-4, Rogers, or ceramic-based materials.

Dimensions: Determine the dimensions of the rectangular patch antenna based on the desired operating frequency and the dielectric constant of the substrate. The patch dimensions are typically in terms of the length (L) and width (W) of the rectangular patch. The resonant frequency of the antenna can be calculated using the formula:

f = c / (2 * sqrt(εr_eff)) * (1 / sqrt(L * W))

Where; 'f' is the desired resonant frequency, c is the speed of light, ε_{reff} is the effective dielectric constant of the substrate.

Feedline Design: Decide on the type of feedline configuration to excite the patch. Common choices include microstrip line, coaxial probe, or aperture-coupled feed. The feedline should be impedance-matched to the characteristic impedance of the microstrip line (typically 50 Ohms) to minimize signal reflections.

Radiation Patch Design: Design the rectangular patch on the substrate based on the desired resonant frequency and other factors such as bandwidth and radiation pattern requirements. The dimensions and shape of the patch can be optimized using numerical simulation tools or analytical formulas such as the cavity model or transmission line model.

Ground Plane: Provide a continuous metallic ground plane underneath the substrate to enhance radiation efficiency and reduce back lobes. The ground plane should be larger than the patch size to minimize edge effects.

Impedance Matching: Adjust the dimensions of the feedline and possibly incorporate matching components like stubs, transformers, or capacitors to achieve impedance matching between the antenna and the transmission line. This ensures maximum power transfer and minimizes signal reflections.

Simulation and Optimization: Utilize electromagnetic simulation software (such as CST Microwave Studio, HFSS, or ADS) to simulate and optimize the antenna design. Perform parametric studies to analyze the effects of different parameters on antenna performance and make necessary adjustments.

Fabrication: Once the antenna design is finalized, the fabrication process can begin. The microstrip patch antenna can be fabricated using standard printed circuit board (PCB) manufacturing techniques. Ensure precision in etching the patch and feedline dimensions to maintain accuracy.

Testing and Validation: After fabrication, perform testing and measurement of the antenna prototype to validate its performance. Measure parameters like return loss, radiation pattern, gain, and bandwidth to ensure they meet the desired specifications.

III. PROPOSE METHOD

The Micro strip antenna was designed by using the Ansoft HFSS. It is one of the designing tools of antenna.

The A soft HFSS is an easy and low-cost tool which has the simple procedures to design the antenna in a very well organized way. By using this software, the antenna should be designed and simulated. By simulating this antenna, we can get the frequency response, gain, directivity and the radiation pattern. There are many analyzing methods are there in the antenna from these we use the transmission line analyzing method for the antenna design, which includes a lot mathematical calculations in the antenna design.

Design Specifications: Determine the desired operating frequency, bandwidth, and other requirement for the antenna based on the specific 5G application. In this case, the target frequency is 28 GHz.

Patch Geometry: Choose a rectangular shape for the microstrip patch antenna. The dimensions of the patch will depend on the desired resonance frequency and the substrate material properties. Typically, the length and width of the patch are fractions of the wavelength at the operating frequency.

Substrate Selection: Select a suitable substrate material that provides the desired dielectric constant and loss tangent. The substrate material affects the antenna's performance, including its impedance matching, bandwidth, and radiation characteristics.

Feeding Mechanism: Determine the feeding mechanism for the patch antenna. Common feeding techniques include coaxial feeding, microstrip line feeding, or aperture coupling. The choice of feeding mechanism will depend on factors such as ease of implementation and desired performance.

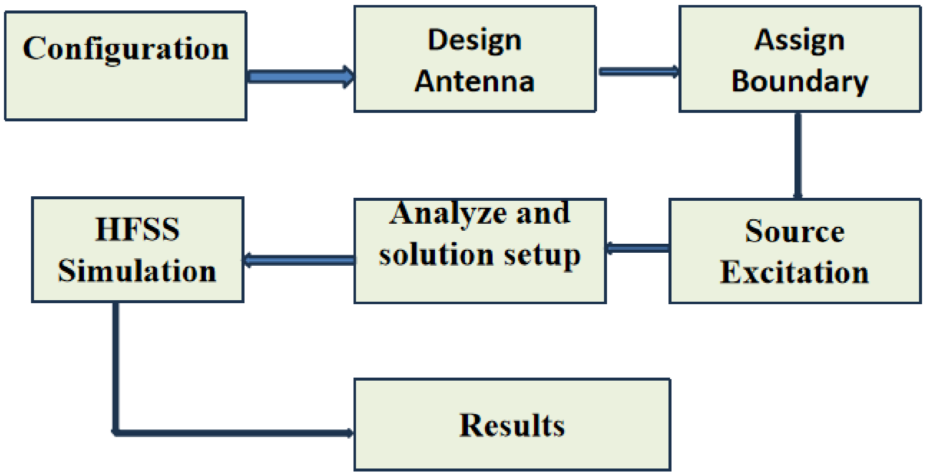

FIGURE 1: BLOCK DIAGRAM OF PROPOSED ANTENNA

Impedance Matching: Optimize the dimensions of the microstrip feed line and the location of the feeding point to achieve good impedance matching between the feed line and the patch. This ensures efficient power transfer and minimizes reflection losses.

IV. RESULT

S-Parameters plot S-Parameters are a way of measuring the scattering or reflection of electromagnetic waves in a network of ports, such as an antenna or a circuit. HFSS is a software tool that can simulate and analyze the S-parameters of various designs using finite element methods. Return loss in HFSS tool is a measure of how much power is reflected back from a Device Under Test (DUT), when connected to a transmission line. It is usually expressed in decibels (dB) and can be calculated from the S_{11} parameter, which is the ratio of the reflected voltage wave to the incident voltage wave at the input port of the DUT The lower the return loss, the better the match between the DUT and the transmission line, and the less power is wasted. In figure2 the return loss is shown at feed width 0.35 mm. The simulated radiation pattern is represented as an M -by-3 matrix where the first column represents the azimuth angle, the second column represents the elevation angle, and the third column represents the radiation pattern in dB. The radiation pattern is shown in the figure 2 and 3.

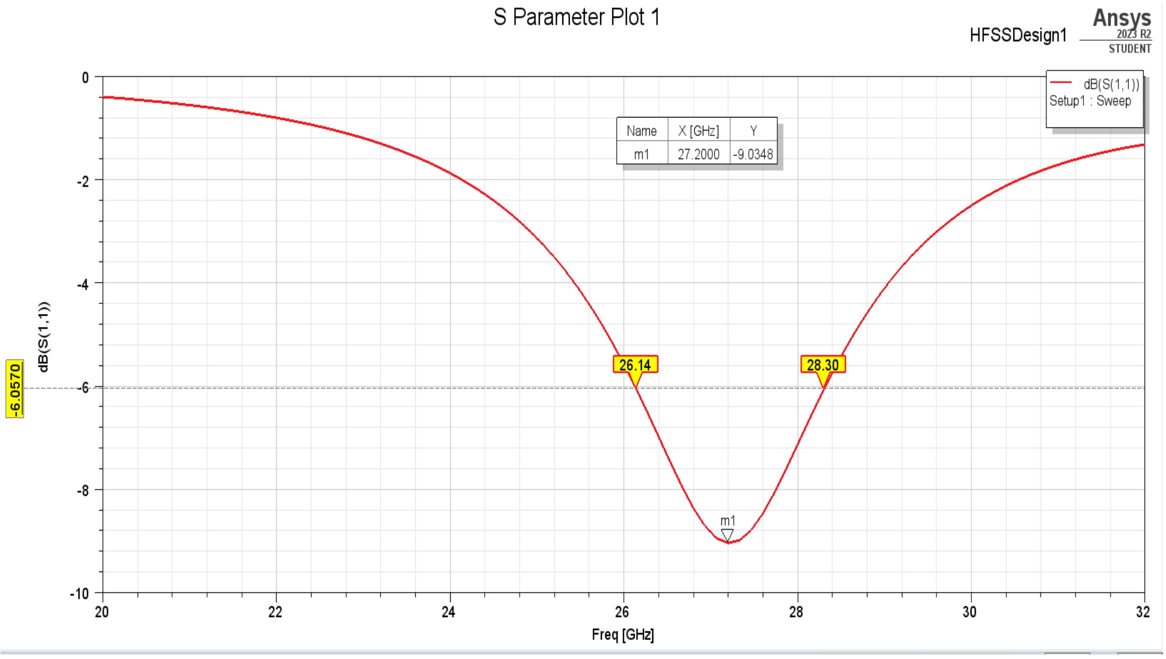

Figure2:Return LossatFeedWidth0.35mm

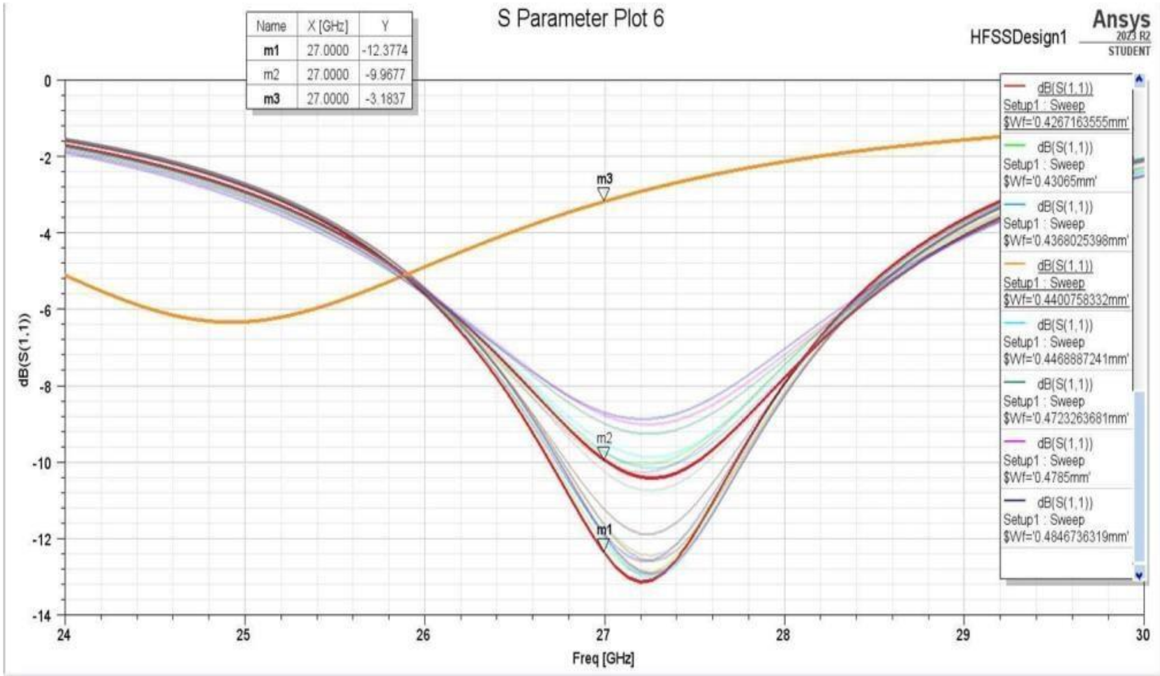

Figure3:Return LossPlotComparisonBetweenFeedWidthat 0.35mm,0.48mm

The performance of an antenna normally depends on a good reflectioncoefficientorreturnloss ofatleast-10dBorbetterthan -15dB.The antenna radiates no power if the reflection coefficient is 0 dB. sincetheantennahas reflectedall ofthepower. sincethereturnloss ofanantennaisaratio ofincomingpowertoreflectedpower,thereturnlossis -12dB at27GHz.

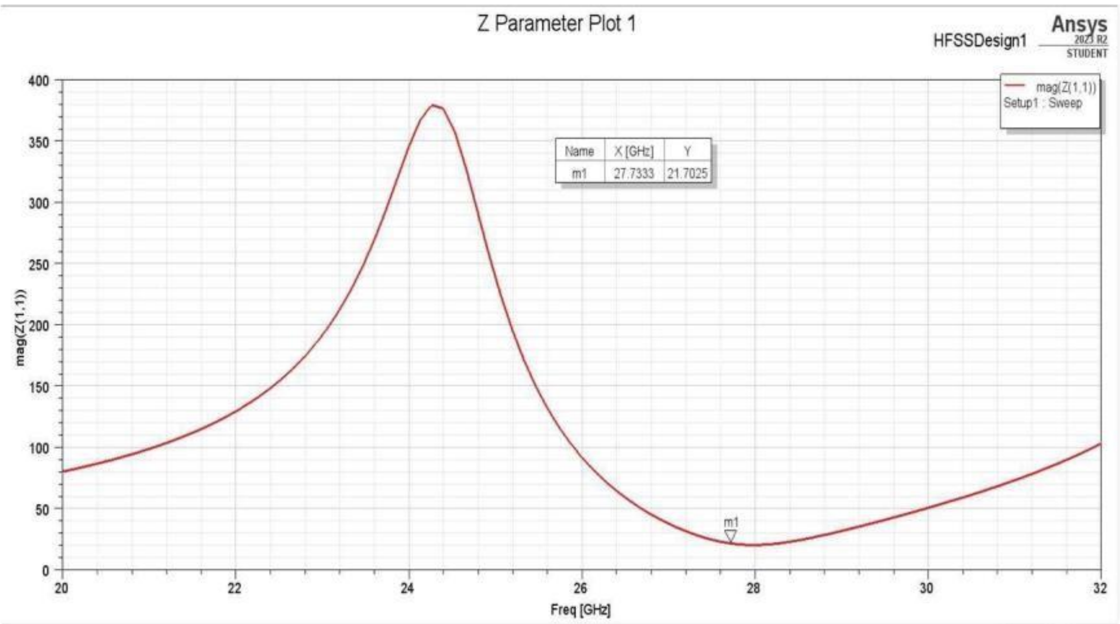

Figure4:ZParameter

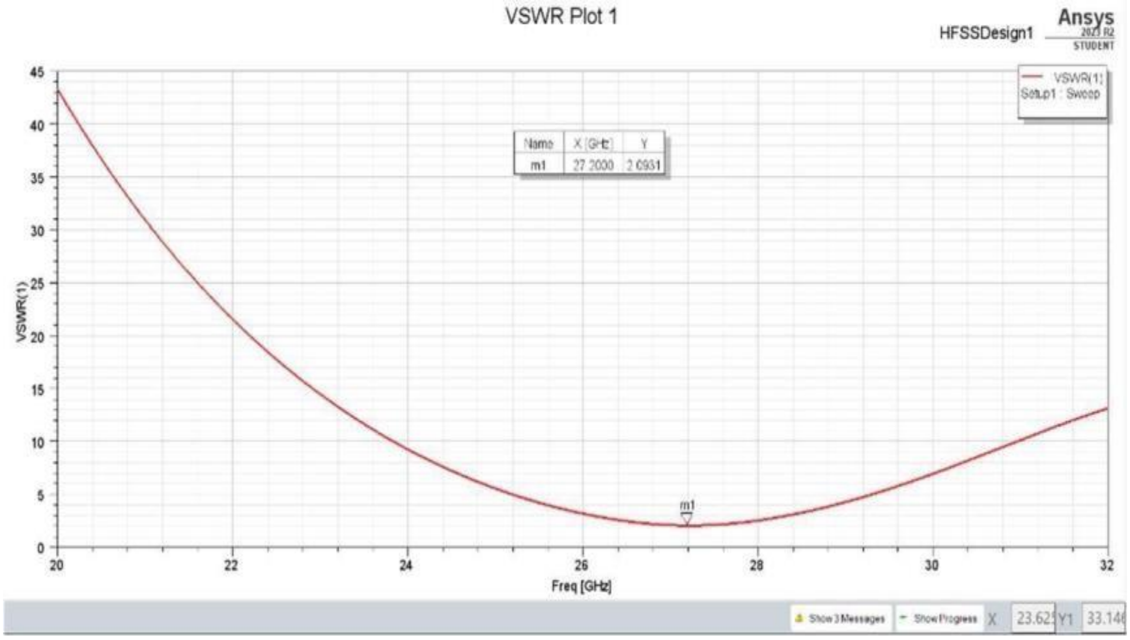

Figure5:VSWR

voltage standing wave ratio and standing wave ratio or standing waveratio. The magnitude of the mismatch increases with increasing VSWR. As aresult,wesuggestthemicrostrippatchantennawhichhasa2.0VSWRat27GHz.TogetagoodqualitytheVSWRshould bein the range of1≤VSWR≤2.

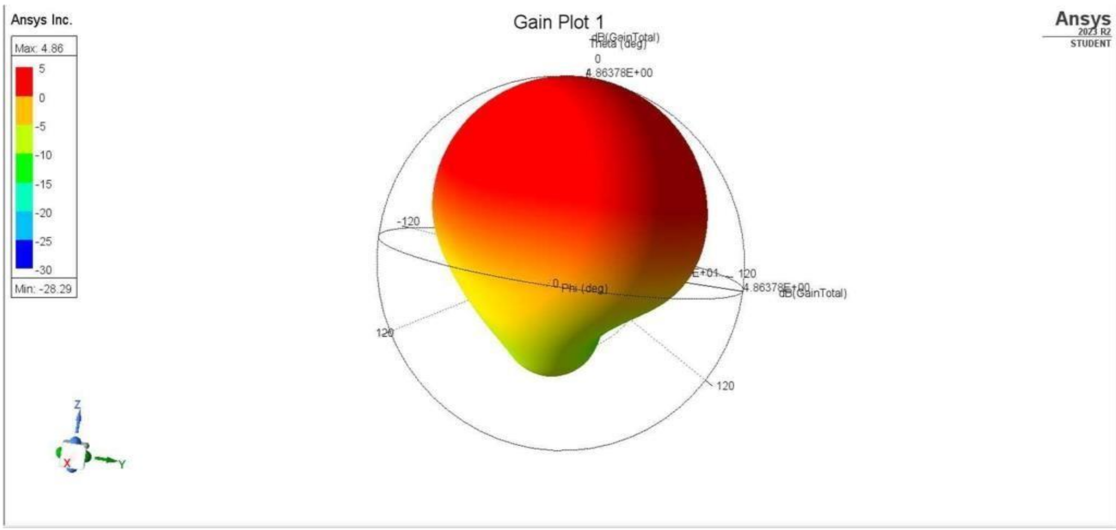

Figure6:3DRadiationPattern

Aradiationpatternisagraphicalrepresentationofhowanantennaradiateselectromagneticwavesintothesurroundingspace.Theradiationpattern of a microstrip antenna depends on its physical dimensions, the dielectricconstant of the substrate, and the frequency of operation. In general, microstripantennas have a directional radiation pattern with maximum radiation in thedirection perpendicular to the patch The radiation pattern defines the variation ofthepowerradiatedby anantenna.

Table5.1:Comparison of the proposed Antenna with Existing Antenna

Description	Existing Method	Proposed Method
	5.2 GHz Frequency \	27 GHz Frequency
Length of entire antenna (mm)	22.8	20
Width of entire antenna (mm)	27.5	17
Height of entire antenna (mm)	1.6	1.575
Gain (dB)	5.25	4.88
Return Loss (dB)	20.3	12.3
Directivity (dBi)	5.66	6.566
Z Parameter	38	45.44

V.CONCLUSION

The paper provides the requirement of wireless communication applications in modern days requires higher data rates and higher capacity. The requirements of higher data rates have further promoted need of antennas with multi bands and low mutual coupling between the antennas. This project begins with learning the historicaldevelopments of antennas in wireless communication then followed by antennaradiationmechanism,typesofvariousantennasandvariousapplications. The proposed MSPA simulation result for operating frequency 27GHz shows that the return loss, directivity, gain and VSWR of -12.3 dB, 6.566 dBi, 4.88 dB and 2.00 therefore, the proposed antenna shows significantly better performance

Overall, the rectangular microstrip patch antenna presents a viable solution for 5G wireless communication systems, offering a balance of performance, size, and ease of integration. Further research and development can focus on enhancing the antenna's performance in terms of gain, bandwidth, and multi-band operation to meet the evolving demands of 5G and future wireless communication technologies.

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