Printed Antenna Design and Simulation for 5G using HFSS

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Abstract -*As the user base grows, so does the need for improved technology. By utilizing the vast quantity of spectrum in the millimeter wave band, fifth generation (5G) technology will be among the best at meeting the demands for huge connection, expanded capacity, and faster speeds. It is anticipated that 5G would provide speeds of 80–100 Mbps. The necessity of 5G technology, antenna design approach, and several simulations are shown. Because of its straightforward physical structure, the micro strip patch antenna utilized in 5G technology is relatively affordable to build and design. Due to its tiny design and multi-band capabilities, the Micro Strip Patch Antenna has become a highly promising option for portable devices. The HFSS program, which is used to design antennas, is utilized to put the suggested notion into practice.*

Key Words:**4G, 5G, UHD, IP, GSM**

1. INTRODUCTION

The role of micro strip patch antennas in modern wireless communication systems is growing. Antennas come in a variety of forms; folding dipole, patch, slot, and parabolic reflector antennas are just a few examples. Every type of antenna has a unique use and a unique set of properties. It is possible to argue that antennas form the foundation of almost everything in wireless communication, without which the modern world would not have progressed to this point in technological advancement. These days, radio frequency (RF) and wireless communication technologies are widely used in many industrial applications as well as daily human activities. In recent years, a plethora of wireless communication technologies have emerged, such as wireless broadband, wireless local area network, wireless interoperability for microwave access, and more. Although the microstrip patch antenna has a restricted bandwidth, a disordered radiation pattern, and weak gain, it is an excellent fit for RF communication systems.

1.1 Statement of the problem

Well, 5G is superior to 4G for a number of reasons. The quicker upload and download speeds are among the key benefits. 5G is more handy for operations like sharing huge files or watching high-definition films since it allows you to download and upload data considerably faster. A further benefit is the decreased latency, which results in a shorter transmission delay for data. A quicker reaction time is essential for real-time applications like gaming and video calls, therefore this is especially significant. Furthermore, without compromising performance, 5G has the ability to accommodate more connected devices concurrently. This is excellent news for smart home technology and the expanding number of IoT devices.

1.2 Objective

The objective of this thesis is to do design and simulation of Printed Antenna Design for 5G Wireless Communications. Antenna with wide band characteristics is designed and simulated using commercial tool HFSS.

1.3 Methodology

Antennas are designed for the frequency range using design considerations and procedures.

- Model the antenna using HFSS.
- Simulating and optimizing design parameters

2. Literature review

In the world of wireless communication networks that we currently inhabit, patch antennas play a critical role. A microstrip patch antenna is relatively simple to construct and uses a more popular microstrip manufacturing technique. Although there is no limit to how the patch may be formed, the most popular forms are rectangular and circular. The most demanding and widest variety of applications are served by these patch antennas in the most straightforward manner . The technical work of several studies on microstrip patch antennas is included in this part. This article proposes a broadband rectangular patch antenna that can be utilized for 5G wireless applications in the future.

The role that patch antennas play in the world of wireless communication networks that we live in is crucial. With S11 values of less than -15 dB, the proposed antenna for 5G communication achieves a broadband impedance bandwidth of higher than 67 percent (from 39GHz to beyond 44GHz). The achieved bandwidth is enough to cover the 28 and 38 GHz bands of the upcoming 5G network. With the exception of the rejected band, the proposed antenna has almost omnidirectional patterns, a comparatively flat gain, and high radiation efficiency throughout the frequency range. Several designs for rectangular microstrip antennas are described in this paper .All of these antennas function at 38 GHz, which is one of the standard frequencies for 5G communications.

An array arrangement uses a corporate feeding network to provide more precise impedance matching. It improves radiation pattern, gain, impedance bandwidth, returns loss characteristics, and other performance elements. Gain and directivity are two further performance indicators that are now benefited by this. A microstrip patch antenna is relatively simple to construct and uses a more popular microstrip manufacturing technique. Although there is no limit to how the patch may be formed, the most popular forms are rectangular and circular. The most demanding and widest variety of applications are served by these patch antennas in the most straightforward manner . The technical work of several studies on microstrip patch antennas is included in this part. This article proposes a broadband rectangular patch antenna that can be utilized for 5G wireless applications in the future.

3. An introduction to HFSS

HFSS utilizes the well-known Microsoft Windows graphical user interface to provide a high-performance full-wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device simulation. It combines solid modeling, automation, simulation, and visualization into a user-friendly environment that makes it simple to get fast, accurate answers to your 3D EM challenges. With Ansoft HFSS, you can solve any of your 3D EM issues with unmatched performance and understanding thanks to the Finite Element Method (FEM), adaptive meshing, and stunning visuals. Fields, Resonant Frequency, and S-Parameters may all be computed using a soft HFSS.

- **Package Modeling:** BGA, QFP, Flip-Chip, PCB
- **Board Modeling:** Power/Ground planes, Mesh Grid Grounds, Backplanes,
- **Silicon/GaAs:** Spiral Inductors, Transformers
- **EMC/EMI:**ShieldEnclosures,Coupling,Near-Field or Far-Field Radiation Antennas/Mobile
- **Communications:** Patches, Dipoles, Horns, Conformal Cell Phone Antennas, Quadrafilar Helix, Specific Absorption Rate(SAR), Infinite Arrays, Radar Cross Section(RCS), Frequency Selective Surfaces(FSS)
- **Connectors:** Coax, SFP/XFP, Backplane, Transitions
- **Waveguide:** Filters, Resonators, Transitions,
- **Couplers Filters:** Cavity Filters, Microstrip Dielectric

3.1 MICROSTRIP PATCH ANTENNA

A lot of academics and researchers have been interested in planar antennas during the past few decades. The need for a tiny, compact antenna that can be combined with MMIC design has grown since the early 1970s large-scale integration and shrinking of electronic circuits. Substrate-based planar antennas are simple to manufacture and integrate with MMICs and PCBs. These antennas have benefits including simplicity of construction, light weight, and low profile.

Designation	Frequency	Typical uses
L band	1 to 2 GHz	Military telemetry, GPS, mobile phones (GSM), amateur radio
S band	2 to 4 GHz	Weather radar, surface ship radar, some communications satellites, microwave ovens, microwave devices/ communications, radio astronomy, mobile phones, wireless LAN, Bluetooth, Zig-Bee, GPS, amateur radio
C band	4 to 8 GHz	Long-distance radio telecommunications
X band	8 to 12 GHz	Satellite communications, radar, terrestrial broadband, space communications, amateur radio, molecular rotational spectroscopy
Ku band	12 to 18 GHz	Satellite communications, molecular rotational spectroscopy
K band	18 to 26.5 GHz	Radar, satellite communications, astronomical observations, automotive radar, molecular rotational spectroscopy
Ka band	26.5 to 40 GHz	Satellite communications, molecular rotational spectroscopy
Q band	33 to 50 GHz	Satellite communications, terrestrial microwave communications, radio astronomy, automotive radar

Table -1: frequency spectrum

Although there are many other types of patch structures, the rectangular, circular, and triangular designs are the most commonly utilized. As planar patch antennas advanced, so did the design of S-band (WIMAX) and C-band (WLAN) antennas.The electromagnetic spectrum's microwave band includes the S-band. It transcends the traditional 3.0 GHz line that separates UHF and SHF frequencies, and is specified by an IEEE standard for radio waves with frequencies that extend from 2 to 4 GHz. Surface ship radar and weather radar both use the S band. Some regions of the electromagnetic spectrum, particularly microwave frequencies utilized in long-distance communications, are referred to as the C-band. The C-band (4 to 8 GHz) and its slightly modified frequencies are utilized by certain Wi-Fi devices, certain cordless phones, and certain weather radar systems.

3.2 Method of microstrip antenna analysis

When scientists discovered that about half of the power in a microstrip radiator escapes as radiation, they understood the significance of microstrip radiators. Consequently, microstrip antennas were characterized as a microstrip emitting patch with a significant radiation loss. Subsequent research demonstrated that the discontinuities at each end of the microstrip transmission line were the source of this radiation process.

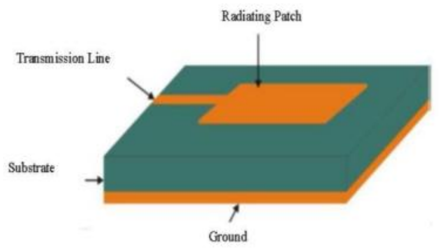

Fig -1: The basic geometry of microstrip radiator

Radiating patches may be built in many different ways, including square, circular, triangle, semicircular, sectorial, and annular ring forms. However, due to their simplicity in manufacture and analysis, rectangular and circular configurations are the most widely utilized.

3.3 Transmission Line Model

According to the transmission line model, as illustrated by Fig the rectangular patch antenna is a parallel plate transmission line that connects to radiating slots that are each of width W and height h. Charge is dispersed throughout the ground plane and the patch's bottom when it is stimulated by a feed line. The attractive forces between the ground plane and the patch's bottom tend to store a lot of charge at any given moment. Additionally, the charges are pushed to the patch's edge by the repulsive forces, which results in a high charge density on the edges.

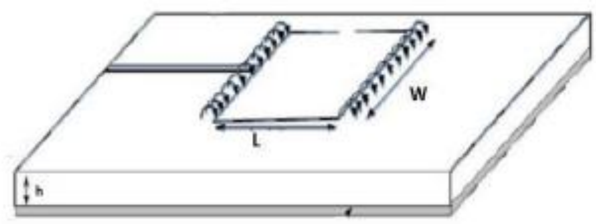

Fig -2: Fringing Fields

4. RECTANGULAR PATCH ANTENNA DESIGN

In wireless communication, an electromagnetic wave is usually radiate into space using a microstrip patch antenna. A microstrip patch antenna consists of four basic parts: feed, patch, substrate, and ground. It has a ground plane on one side and a dielectric constant on the other, and it can be square, elliptical, circular, rectangular, or ring-shaped. Microstrip patch antennas are used in many different applications, such as microwave communication, global positioning system (GPS), logistics tracking, and automotive. A microstrip antenna is depicted in Figure, where W represents width, L represents length, and ε represents the effective dielectric constant of the rectangular patch.

4.1 Designing of rectangular patch antenna

4.1.1 Determine Design Parameters:

Frequency: Define the operating frequency or frequency range of your antenna. Dielectric Substrate: Choose a suitable dielectric substrate material. FR4 is commonly used. Permittivity (εr): Select the permittivity of the substrate material. Patch Dimensions: Determine the major and minor axes of the rectangular patch

4.1.2 Calculate Patch Dimensions:

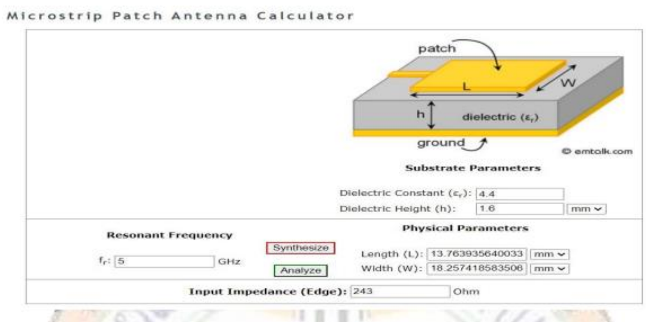

Fig -3: patch calculator

Parameters	Dimensions (mm)
Resonance Frequency	38 GHZ
Dielectric Constant(FR4_EPOXY)	4.4
Length of the substrate	6.2
Width of the Substrate	7.4
Height of the patch	0.035
Height of the substrate	1
Width of the patch	2.5
Length of the patch	3.5
Width of the feedline	0.75

Table-2: Dimensions of the antenna

5. Design of rectangular patch antenna in HFSS

- **Step 1:** creating a ground plane Material: copper
- **Positions:** 0,0,0 X size: length of the substrate Y size: width of the substrate Z size: height of the patch

- **Step 2:** creating a substrate Material: FR4-epoxy Positions :0,0,0.035 X size: length of the substrate Y size; width of the substrate Z size: height of the substrate

- **Step 3:** creating a patch Material: copper Positions: A,Ws/2-Wp/2,Hp+Hs X size: length of the patch Y size: width of the patch Z size: height of the patch

- **Step 4:** inset feed

  Material: copper Position: A+Lp, Ws/2-Wf/2,Hp+Hs X size: Ls-A-Lp Y size: width of the feed Z size: height of the patch

- **Step 5:** giving excitation Position: Ls,Ws/2-Wf/2,(Hp+Hs) Y size: width of the feed Z size: -(Hp+Hs)

- **Step6:**creating radiation boundary Operatingfrequency: 15 GHz

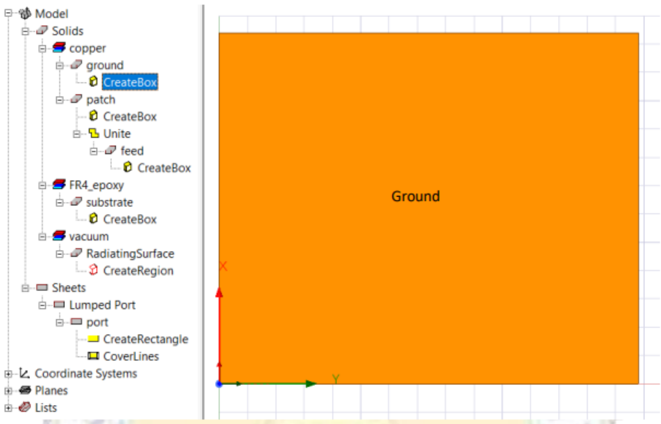

Fig -4: Applying ground

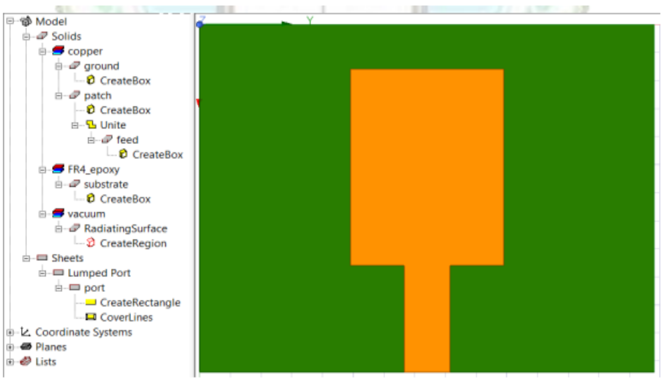

Fig -5: Applying substrate

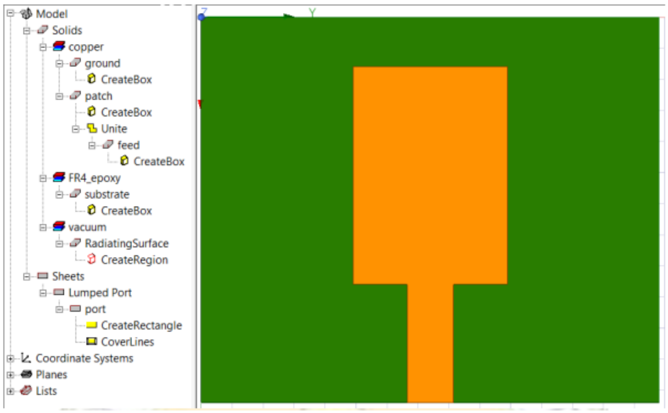

Fig -6: generating patch

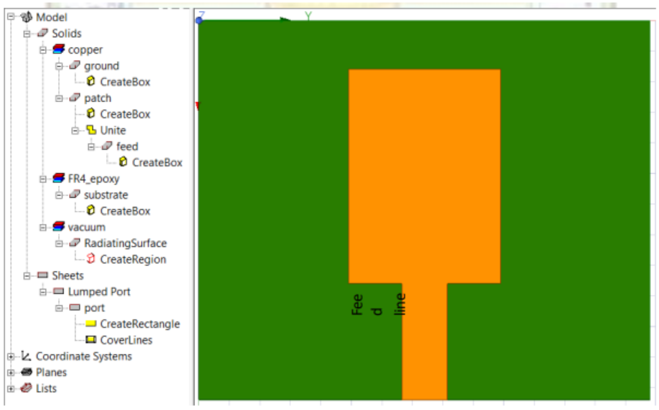

Fig -7: Inset feed line

6. Results

Return loss: The parameter was determined to be accurate based on the simulation final results. The base value is -6dB, which is idle for mobile and wireless technology. The antenna is tuned to the required frequency to function properly. As can be seen in the below figure, it runs at a frequency of 42.15GHz,S11 parameter describes the return loss of the designed antenna. the value of return loss is -30.54dB which is very high ensuring perfect candidate for 5G applications.

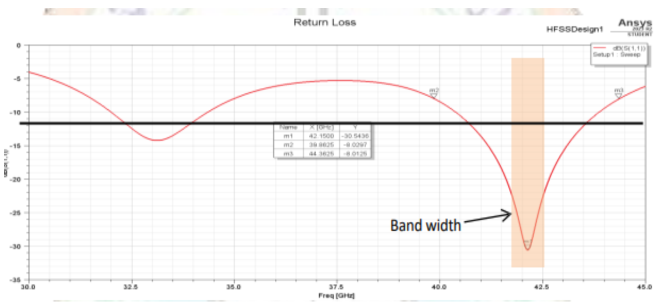

Fig -8: Return loss

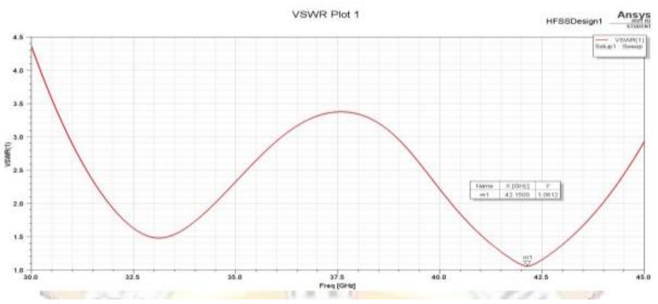

Fig -9: VSWR

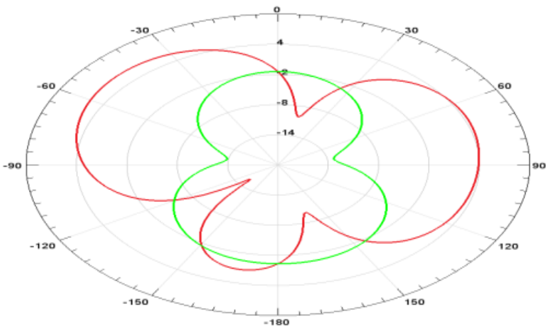

Fig -10: Radiation pattern

The radiation pattern of an antenna refers to the directional distribution of its electromagnetic energy in the space. plot or graph showing the antenna's signal strength as a function of angle.

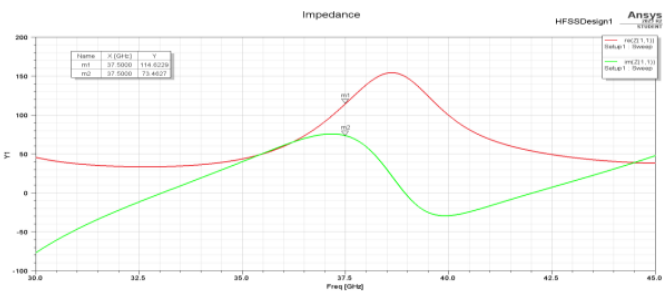

Fig -11: Impedance

Fig -12: Diectivity

7. Conclusion

In this study, a microstrip patch antenna with a resonance frequency of 42.15GHz is constructed, simulated, and the results of the simulation are recorded using FR-4 epoxy as the substrate. To create an antenna, one uses the inset feeding approach. Rectangular patch antennas have a 4.5GHzbandwidth.the computer programwith the use of a rectangular patch antenna and HFSS software.

Parameters	Results Obtained By Us
Return Loss	-30.54db
Resonance Frequency	42.15GHz
Bandwidth	4.5GHz
Highest Radiation Intensity	6.06db
Directivity	4.92db
VSWR	1.06db

Table-2: Results

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