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OPTIMIZATION OF PRINTED DIPOLE ANTENNA PERFORMANCE FOR WIRELESS COMMUNICATION SYSTEMS

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Abstract - *Antennas are crucial components of wireless communication systems because they provide dependable signal transmission and reception. Printed dipole antennas have drawn a lot of interest because of their small size, cheap profile, and simplicity of production. The goal of this study is to improve the printed dipole antenna's performance so that it may be used in more wireless communication applications.*

The goal of the optimization method is to improve important antenna characteristics including gain, bandwidth, radiation pattern, and impedance matching through thorough study and design considerations. Advanced simulation techniques are used to precisely simulate the antenna construction and forecast its performance characteristics. These approaches include the method of moments (MoM) and the finite element method (FEM). Several optimization techniques are investigated, including feeding methods, substrate selection, and geometrical adjustments. Through simulation studies, the effects of various factors, including substrate dielectric constant, dipole width, length, and spacing, on antenna performance are methodically examined. In addition, practical aspects like manufacturing limitations and environmental influences are taken into account to guarantee the viability and dependability of the optimized antenna design. To verify the simulation results, printed dipole antenna prototypes that have been optimized are constructed and tested experimentally.

1. INTRODUCTION

The role of microstrip patch antennas in modern wireless communication systems is growing. Antennas come in a variety of forms; some of the more common ones include parabolic reflectors, patch antennas, slot antennas, and folding dipole antennas. Every type of antenna has a distinct set of qualities and a specific use. 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 extensively 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 networks, and wireless interoperability for microwave access. Although the microstrip patch antenna has a restricted bandwidth, a disordered radiation pattern, and weak gain, it is an excellent fit for RF communication system demands. Because of the wide range of wireless applications, this issue has attracted the attention of scientists and researchers. The idea of a microstrip patch antenna, a novel electrical technology that may be manufactured on printed circuit boards, has been reported by several researchers. In today's wireless communication systems, they are crucial. The Latin word "antenna" is the source of the word "antenna." "A component of a transmitting or receiving system designed to radiate or receive electromagnetic waves" is how the IEEE defines an antenna. Using a conventional microstrip manufacturing method, creating microstrip antennas is quite easy. Lower efficiency results from designing a small microstrip patch antenna with a substrate that has a higher dielectric constant. Applications for fifth-generation (5G) technology are expanding quickly in the current era of technology. It may offer a wide range of services, including remote industrial equipment control and medical care. Additionally, it ensures security and advances a nation's economic progress by improving societal safety.

1.1 Statement of the problem

Well, there are a few reasons why 5G is superior to 4G. A primary benefit is the increased upload and download speeds. The speed at which 5G can download and upload files makes it more convenient for operations like sharing huge files or watching high-definition films. Lower latency, or less delay in data transmission, is an additional benefit. This is particularly significant for real-time applications where a quicker reaction time is essential, such as video calls or gaming. Furthermore, 5G may be able to accommodate more connected devices concurrently without compromising speed. For the expanding number of IoT devices and smart home technologies, this is excellent news.

1.2 Objective

Designing and simulating printed antenna design for 5G wireless communications is the goal of this thesis. Using the commercial tool HFSS, an antenna with wide band properties is developed and simulated.

1.3 Methodology

Using design considerations and methods, an antenna is created for the desired frequency range.

- Create an HFSS model for the antenna.
- Modeling and refining design parameters.

2. Literature review

In the age of wireless communication networks, patch antennas play a critical role in meeting various needs. A microstrip patch antenna may be constructed using a relatively simple technique that makes use of a more widely known microstrip manufacturing process. Although the patch may be set up in any way possible, the most popular configurations are circular and rectangular. For the widest variety of applications—which are also the most demanding—these patch antennas are used in the most straightforward manner conceivable. The technical work of several studies on microstrip patch antennas is included in this part. This article [8] suggests a broadband rectangular patch antenna that may be utilized for upcoming 5G wireless applications. 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 44GHz). The achieved bandwidth is enough to cover the 28 and 38 GHz bands of the upcoming 5G network. Except for the rejected band, the proposed antenna has almost omnidirectional patterns, a comparatively flat gain, and high radiation efficiency throughout the frequency range. In this investigation, With the use of slotting techniques with favorable return loss, favorable gain, and VSWR less than 2, the suggested antenna was able to successfully resonate at three distinct frequencies: 31 GHz, 34.2 GHz, and 38.4 GHz. This is a useful notion for rapid internet access and wireless connection establishment.

3. An introduction to HFSS

Utilizing the well-known Microsoft Windows graphical user interface, HFSS is a powerful full-wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device simulation. Its easy-to-learn framework combines solid modeling, automation, simulation, and visualization to provide fast and accurate solutions for your 3D electromagnetic challenges. With Ansoft HFSS, you can solve any 3D EM issue with unmatched performance and understanding thanks to the Finite Element Method (FEM), adaptive meshing, and stunning visuals. Fields, resonance frequency, and S-parameters may all be computed using a soft HFSS.

3.1 Plotting Data

There are several ways to plot data. While we may plot in 3D as well, 2DCartesian charting is the most commonly used format. Enumerated here are all the quantities that are plottable on different graphs. Consult the online assistance for explanations of each of these quantities.

- **Eigenmode solution**
- **Eigenmode Parameters (modes)**
- Driven Modal Solution S-parameters•
- Y-parameters
- Z-parameters
- VSWR
- Gamma (complex propagation constant)
- Port Zo
- Driven Terminal Solution
- S-parameters
- Y-parameters
- Z-parameters
- VSWR
- Power (at port) Voltage Transform matrix (T)
- Terminal Port Zo
- **Fields**
  - Mag_E
  - Mag_H
  - Mag_Jvol
  - Mag_Jsurf
  - ComplexMag_E
  - ComplexMag_H
  - ComplexMag_Jvol
  - ComplexMag_Jsurf
  - Local_SAR (Specific Absorption Rate)
- **Types of Plots:**
  - Rectangular Plot
  - Polar Plot

- 3D Rectangular Plot
- 3D Polar Plot
- Smith Chart
- Data Table
- Radiation Pattern

4. DIPOLE ANTENNA

An essential type of radio frequency antenna is the dipole antenna, sometimes known as the dipole aerial. A more complex antenna array may include the dipole or it might be used alone. The dipole aerial, commonly known as an antenna, is frequently used both independently and in many different RF antenna designs as the radiating or driving part of the antenna as a whole. The dipole's basic operation is rather simple, and many of the computations involved are also very simple. An HF, VHF, and UHF portion of the radio frequency spectrum may be easily operated by designing a simple dipole antenna. Nevertheless, a more complex mathematical approach may be necessary for a thorough mathematical examination.

4.1 MICROSTRIP PATCH ANTENNA

A large number of researchers and academics have shown interest in planar antennas throughout the past few decades. A tiny, compact antenna that can be integrated with MMIC design has become more and more in demand since the early 1970s revolution in electronic circuit shrinking and large-scale integration. The substrate-based antennas known as planar antennas are simple to fabricate and integrate with MMICs and PCBs. Low profile, small weight, and simplicity of construction are some of the benefits of these antennas.

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: spectrum of frequencies

4.2 Technique for analyzing microstrip antennas

When scientists discovered that about half of the power in a microstrip radiator escapes as radiation, they understood the significance of microstrip radiators. Consequently, a microstrip antenna was described 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. A patch antenna's fundamental design consists of a flat plate placed over a ground plane and a dielectric substrate.

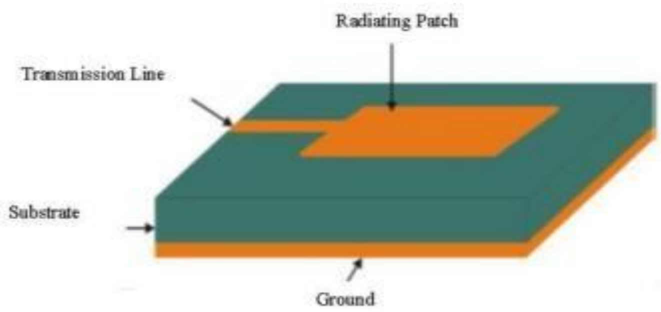

Fig -1: The fundamental geometry of a microstrip radiator

4.3 Transmission Line Model

According to the transmission line concept, the rectangular patch antenna, as seen in Fig is a parallel plate transmission line connecting to radiating slots that are each width W and height h. The 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.

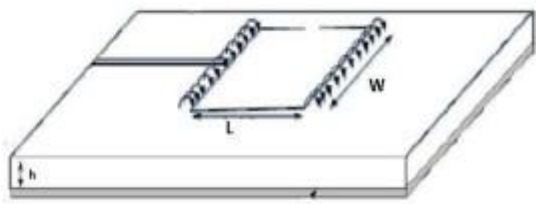

Fig -2: Fields on the Edge

5. PRINTED DIPOLE ANTENNA DESIGN

In wireless communication, an electromagnetic wave is usually radiated 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 tracking logistics and automobiles. microwave communication and the global positioning system (GPS). A microstrip antenna is depicted in Figure, where W denotes width, L denotes length, and ε represents the effective dielectric constant of the rectangular patch. The creation of a patch antenna for wireless communication is covered in this section as it is widely known that these antennas may be installed on printed circuit boards (PCBs) for a variety of communication devices.

Sample paragraph Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

5.1 Printed Dipole Antenna (Differential Feed)

Ansoft Designer is used to create and simulate a printed dipole antenna with a differential feed in this lesson. When an omnidirectional pattern is needed for planar microwave radiative applications, the printed dipole antenna is frequently utilized. Fig. 1 displays the printed dipole model. The feed gap (g) and substrate height (h) will remain stable, and the dipole arm's width (W) and length (L) will be tuned for 3.0 GHz operation. There is an outline of the model and simulation setup.

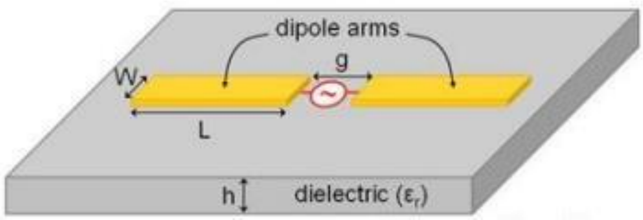

Fig -3: A differential feeding-based printed dipole antenna model.

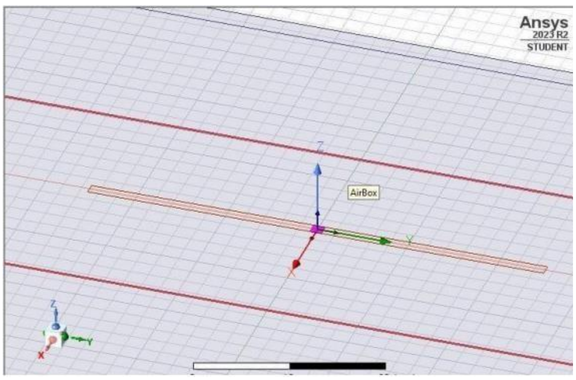

Fig -4: Execution Setup

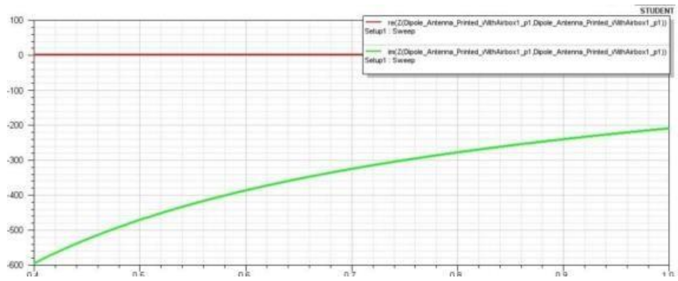

Fig -5: The unoptimized printed dipole's input impedance.

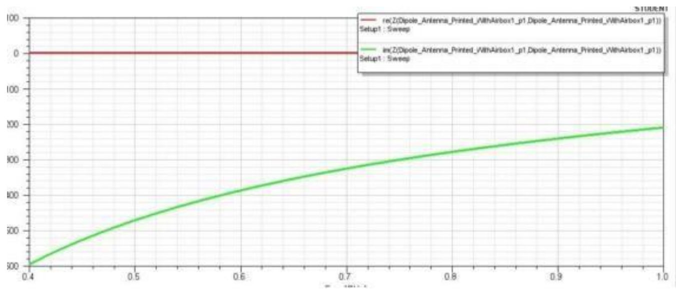

Fig -6: The unoptimized printed dipole's input impedance.

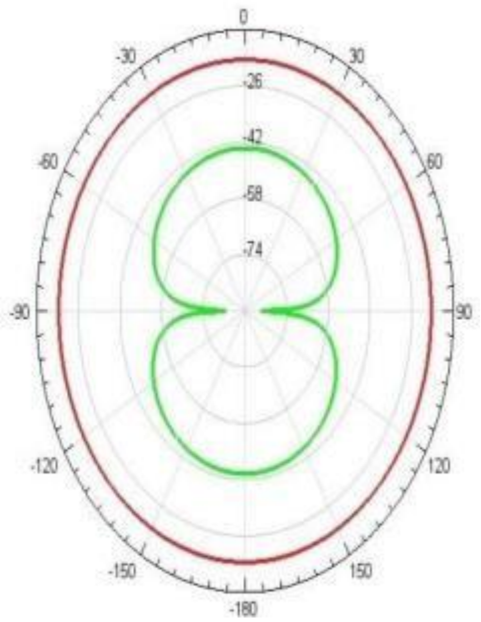

Fig -7: optimal dipole length input impedance.

5.2 Dimensions of the antenna

Parameters	Dimensions (cm)
Airbox _dist	4.1638cm
Antenna_width	0.13cm
Port_gap_width	0.13cm
Dipole_length	5.03cm
Sub H	62mil
Sub X	7.5cm
Sub Y	10.1cm

Table 2: The antenna's measurements

6. RESULTS

Based on the outcome of the simulation, it was concluded that the parameter was correct. For mobile and wireless technologies, the basic value is -1.04 dB, which is idle. For optimal operation, the antenna is set to the necessary frequency. The S11 parameter characterizes the return loss of the planned antenna, and the frequency of operation is 1.1GHz, as shown in the picture below. Return loss's value is

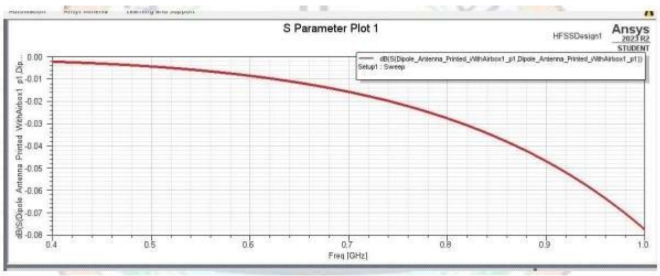

Fig -8: Return loss

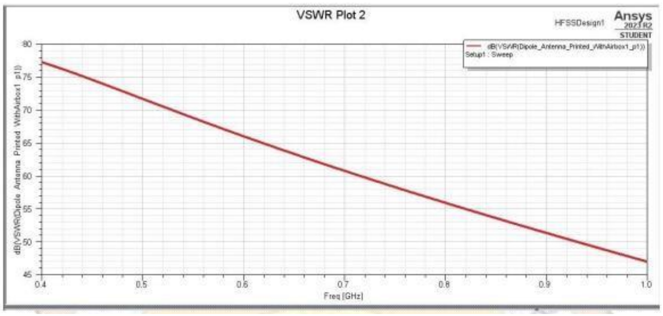

Fig -9: VSWR

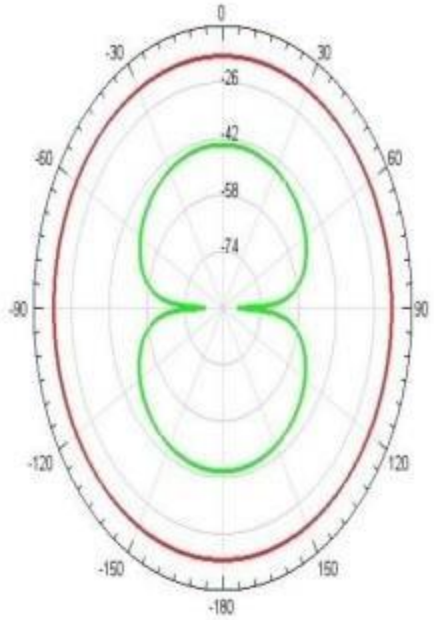

Fig -10: Radiation pattern

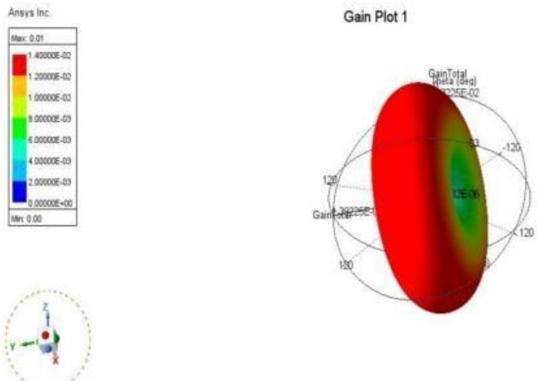

Fig -11: Gain

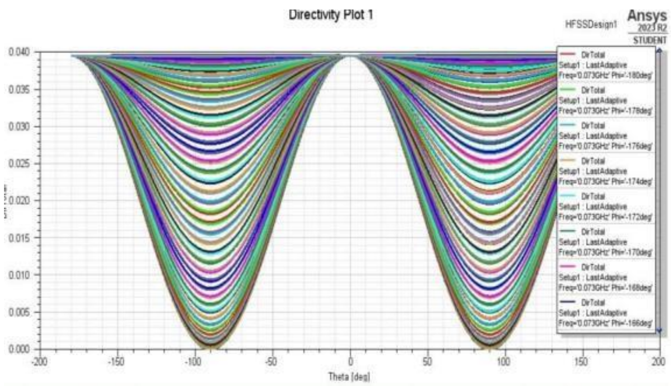

Fig -12 Directivity

3. CONCLUSIONS

In this work, a printed dipole antenna with a resonance frequency of 0GHz is created, and simulated, and the results of the simulation are recorded at my_mat_ADK as the substrate. A printed dipole antenna has a 1.1GHz bandwidth. Using HFSS software, the printed dipole antenna is simulated.

Parameters	Results Obtained By Us
Return Loss	-1.04db
Resonance Frequency	0Hz
Bandwidth	1.1GHz
Highest Radiation Intensity	0.01db
Directivity	0.073db
VSWR	77db

Table-3: Comaparission

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