DESIGN OF HIGH-GAIN MAGNETO-ELECTRIC DIPOLE ANTENNA BY LOAING A MAGNETO-ELECTRIC DIPOLE DIRECTOR

A PROJECT REPORT

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BONAFIDE CERTIFICATE

Certified that this project report **"DESIGN OF HIGH-GAIN MAGNETO-ELECTRIC DIPOLE ANTENNA BY LOADING A MAGNETO-ELECTRIC DIPOLE DIRECTOR"** is the bonafide work of **"Anbarasi S, Jaipriya S, Praveena M, Subasri S"** who carried out the project work under my supervision.

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INTERNAL EXAMINER EXTERNAL EXAMINER

ABSTRACT

Foremost, we express our deep gratitude to the almighty for his grace and blessings upon us to complete the project. We convey our special gratitude and thank to our Dean **Dr.G. SENTHIL KUMAR M.Sc., M.Phil., Ph. D.,** for providing us with necessary facilities for the completion of our project and helping us with their valuable inputs.

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The design of a high-gain magneto-electric dipole antenna involves enhancing the antenna's performance through the addition of a magneto-electric dipole (ME-Dipole) director. This approach is particularly effective in improving the antenna's gain and bandwidth characteristics. The ME-Dipole director is added on top of a conventional cavity-backed ME-Dipole antenna, which serves as the base structure. The addition of the ME-Dipole director aims to increase the antenna's gain and efficiency, making it suitable for various applications requiring high-gain antennas.

This design strategy is part of a broader effort to develop compact, wideband, and high-efficiency antennas that can operate across a wide frequency range while maintaining excellent radiation characteristics. The integration of ME-Dipole directors with cavity-backed ME-Dipole antennas represents a significant advancement in antenna design, offering improved performance in terms of gain, bandwidth, and radiation pattern stability.

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CHAPTER 1

1.1INTRODUCTION

Communication system have been said to have a rapid growth and has been attracting interest for the last few years. Communication among humans occurred first by sound through voice. This process later led to the urge for new mediums for higher distance communication systems such as smoke and flag signals.

5G Technology stands for 5th Generation Mobile technology. 5G technology has changed the means to use cell phones within very high bandwidth. User never experienced ever before such a high value technology. Nowadays mobile users have much awareness of the cell phone (mobile) technology. The 5G technologies include all type of advanced features which makes 5G technology most powerful and in huge demand in near future.

The magneto-electric dipole antenna revolutionizes antenna design, offering enhanced radiation efficiency and broader bandwidth through simultaneous manipulation of electric and magnetic fields. Its compact size, driven by magneto electric materials, suits space-constrained applications. Integration of magneto electric dipole directors enhances directivity and signal strength, making it ideal for diverse applications, from wireless communication systems to radar and satellite communication.

In this we are going to design a magneto-electric dipole antenna enhanced by loading a magneto-electric dipole director represents a cutting-edge advancement in antenna technology. By strategically incorporating the dipole director into the antenna structure, it modifies the radiation characteristics, improving directivity and gain.

The box-shaped reflector in magneto-electric dipole antennas enhances performance by directing and focusing radiated energy. Positioned behind the antenna element, it improves directivity and reduces interference, increasing gain. This unique feature optimizes antenna performance, making it ideal for applications requiring enhanced signal strength and cover.

1.2 Statement of the Problems

The Radiators are fundamental components in antenna design as they are responsible for converting electrical signals into electromagnetic waves, which propagate through space to transmit or receive information wirelessly. The radiator's structure and properties determine key antenna characteristics such as radiation pattern, polarization, and efficiency. By carefully designing and optimizing radiators, antennas can be tailored to meet specific performance requirements for various applications, including communication, radar, navigation, and remote sensing. Thus, radiators serve as the primary means of interfacing between electronic circuits and the electromagnetic field, enabling wireless communication and connectivity in modern technology.

The upper case gamma feedline in a ME- dipole antenna efficiently transfers electromagnetic energy from the transmitter or receiver to the antenna radiator comparatively. It is designed for impedance matching, ensuring minimal signal loss and optimal performance. This feature contributes to the antenna's effectiveness in transmitting or receiving signals for various applications in radar systems.

The performance characteristics of a ME-dipole antenna antenna can be influenced by various parameters, including the dimensions and shape of the Director, the dielectric constant of the substrate, the feed location, and the ground plane size. By adjusting these parameters, the antenna's operating frequency, bandwidth, radiation pattern, and impedance matching can be optimized to meet the specific requirements of the application.

The problem statement involves analyzing the performance of a magneto-electric dipole antenna when a magneto-electric dipole director is loaded onto it. This includes examining how the addition of the director affects the antenna's radiation pattern, impedance matching, and overall efficiency.

By adding a magneto-electric dipole director alters these characteristics. This analysis may involve simulations, theoretical calculations, or experimental measurements to quantify the changes in performance and optimize the antenna design for specific applications.

1.3 Aim and Objectives

The aim of this project is to design, analyze, and optimize a magneto-electric dipole antenna for efficient transmission and reception of electromagnetic waves across a specified frequency range.

The objective of the magneto-electric dipole antenna project is to design, construct, and analyze an antenna that combines both magnetic and electric dipole elements to achieve enhanced performance characteristics such as improved radiation efficiency, wider bandwidth, and better impedance matching compared to traditional antennas.

1.4 Significance of Study

The study of magneto-electric dipole antennas holds significant promise in advancing antenna technology. By harnessing both magnetic and electric properties, these antennas offer the potential for improve performance metrics such as higher gain, broader bandwidth, and better efficiency compared to conventional designs.

Additionally, their versatility allows for customization of radiation patterns and polarization states, making them adaptable to various communication scenarios. Understanding magneto-electric dipole antennas could lead to innovations in miniaturization, multi-band operation, and interdisciplinary research, ultimately enhancing the performance and efficiency of wireless communication systems in diverse applications.

1.5 Scope of Study

The study of magneto-electric dipole antennas covers design, analysis, and optimization, exploring novel configurations, materials, and performance metrics.

It extends to practical applications like wireless communication, radar systems, and sensing technologies, aiming to advance antenna technology and develop efficient communication systems.

1.6 Overview of ME-DIPOLE Antenna by loading a ME-DIPOLE director

The concept of a magneto-electric dipole antenna loaded with a magneto-electric dipole director represents a significant advancement in antenna design.

By integrating both magnetic and electric properties, this configuration offers enhanced performance characteristics compared to traditional antennas.

The addition of a magneto-electric dipole director allows for precise control of the antenna's radiation pattern, enabling features such as improved directivity, beam steering capability, and frequency bandwidth enhancement. Moreover, loading the antenna with a director can lead to size reduction and compactness without sacrificing performance, making it suitable for applications with space constraints.

This innovative approach opens up opportunities for advancements in wireless communication, radar systems, and sensing technologies, promising more efficient and reliable antenna solutions for various real-world applications.

1.7 Categories of waves on ME-DIPOLE antenna

The method involving the transmission and radiation in a ME-DIPOLE antenna can be understood considering a point current source (Hertz dipole) located on top of the grounded dielectric substrate (fig 1.1). This source radiates electromagnetic waves depending on the direction where the waves are transmitted; they consist of two distinct categories with different behaviour.

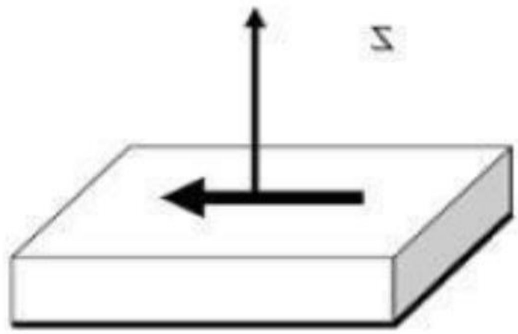

Figure 1.1: Hertz dipole on a substrate

1.7.1 Surface Waves:

This involves the waves are transmitted slightly downward, having elevation angle ϴ between 2 and – arc sin (1/√) meet the ground plate, which in turn reflects them, towards the dielectric-to-air boundary, which in turn reflects them (total reflection condition). The magnitude of the field amplitude increases for some particular incidence angles leading to an excitation of a discrete set of surface wave modes. This occurs to the rapid decay of the dielectric above the surface due to the field mostly trapped within it. The wave is a non-uniform plane wave.

The direction of largest attenuation (the vector α) pointing upwards; the wave propagates horizontally across β with little absorption in good dielectric. The surface waves take up some part of the signals energy, which does not reach the intended user. This leads to a reduction in the impedance, contributing to the decrease in the efficiency of the antenna.

Also, surface waves introduce spurious coupling between different circuit or antenna elements. This effect drastically reduces the performance of the ME-dipole filters because the parasitic interaction reduces the isolation in the stop bands.

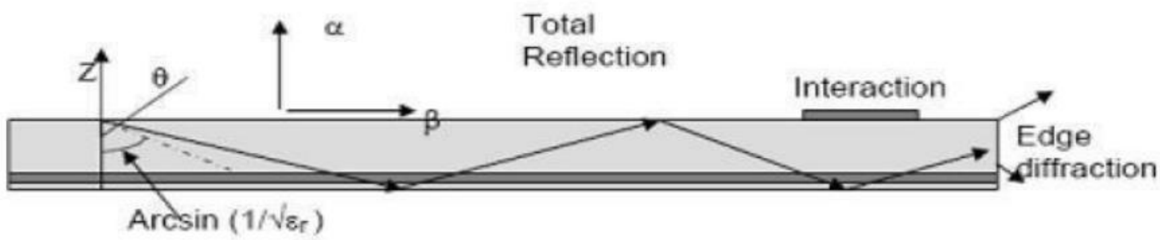

Fig 1.2 : Surface Wave

1.7.2 Leaky Waves:

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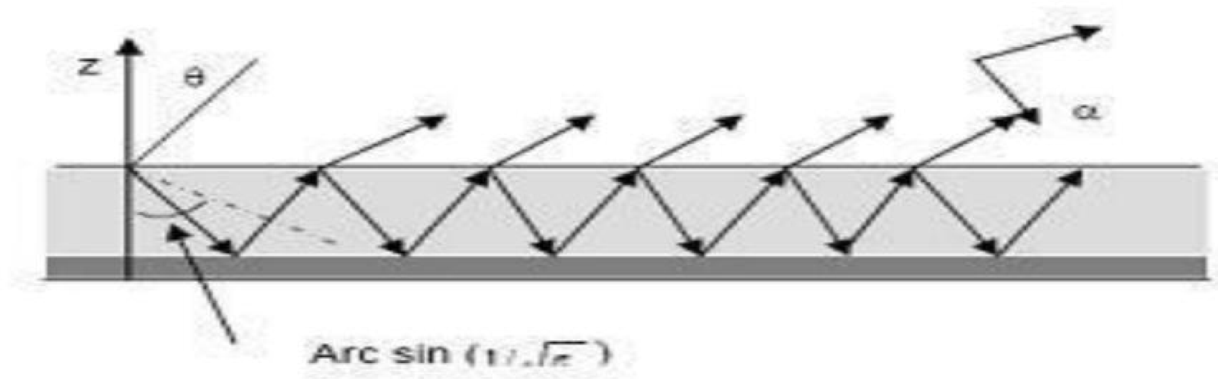

Fig 1.3 : Leaky Waves.

1.8 Directional Antenna:

A directional antenna for the magneto-electric dipole antenna can be achieved by designing its structure to concentrate radiation in specific directions while suppressing radiation in others.

One common type of directional antenna is the Yagi-Uda antenna, which consists of a driven element (the magneto-electric dipole), one or more parasitic elements, and a reflector element.

In the context of a magneto-electric dipole antenna, the design can be optimized to achieve directional radiation patterns by adjusting the lengths and positions of the antenna elements.

The parasitic elements are strategically placed to enhance radiation in the desired direction(s) by creating constructive interference, while the reflector element helps to focus radiation forward and increase directivity.

Directional antennas are valuable for applications where long-range communication is required, such as point-to-point links, wireless backhaul, and satellite communication.

By focusing the antenna's radiation in specific directions, directional antennas can improve signal strength, increase communication range, and reduce interference from unwanted directions.

1.9 Radiation Pattern:

Radiation pattern of an antenna is described as an electromagnetic wave, for the course of this research the concentration point is the measuring and calculating the strength of this electromagnetic wave at a point where the wave is in plane wave and normal to the direction of the antenna. Radiation pattern is the difference of the electric field as a function of angle and has two field components namely the E and H field vectors. The radiation pattern can be represented using the Cartesian or polar coordinates (fig1.4).

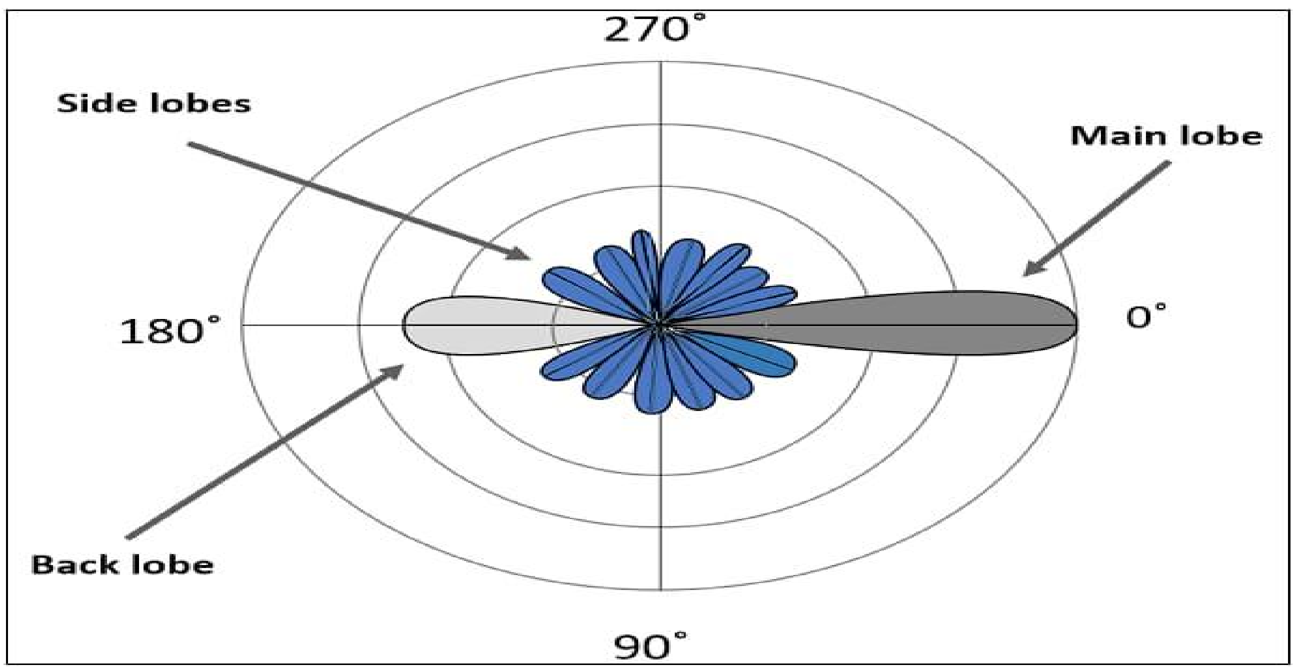

Fig 1.4 Radiation pattern consisting of the cartesian and polar diagram

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The radiation pattern provides valuable information about the performance and characteristics of an antenna or radiating element. It helps in analyzing and optimizing the antenna's efficiency, gain, directivity, beamwidth, and polarization properties. By studying the radiation pattern, engineers can determine how the antenna radiates energy in different directions and adjust its design parameters accordingly to achieve desired performance.

1.10 Organization of the work

Chapter 1 provide the background, motivation, Aim &objective, significance and scope of the proposed work.

Chapter 2 consists of Literature survey related to the proposed work.

Chapter 3 involves the design of the antenna; including the use of specialized software and the construction of the antenna.

Chapter 4 consist of the antenna parameters and the analysis of the Antenna in terms of Radiation Pattern.

Chapter 5 includes conclusions and future scope of this project work

CHAPTER-2

LITERATURE SURVEY :

[1]A. Skandalakis et al.,2022 IEEE explores the analysis of a planar magneto-electric dipole antenna designed for LTE, WLAN, and WiMAX applications. This research addresses the growing demand for versatile antennas capable of supporting multiple wireless communication standards efficiently. The antenna's planar configuration suggests potential advantages in terms of compactness and ease of integration into various devices and systems.

Through rigorous design optimization and simulation-based analysis, the authors investigate the antenna's performance across different frequency bands relevant to LTE, WLAN, and WiMAX. Parameters such as radiation characteristics, impedance matching, bandwidth, and efficiency are thoroughly evaluated to ensure optimal functionality. The study likely presents comprehensive simulation results illustrating the antenna's radiation patterns, return loss, and bandwidth characteristics, providing valuable insights into its performance capabilities.

The findings of this analysis contribute to advancing the understanding of magneto-electric dipole antennas and their applicability in modern wireless communication systems. The antenna's broadband performance and compatibility with multiple frequency bands make it a promising candidate for various practical applications. By elucidating the design principles and performance metrics of such antennas, this research paves the way for the development of more efficient and versatile communication technologies.

[2]J. Hu et al.,2021 IEEE present a comprehensive investigation into the design and optimization of a broadband magneto-electric dipole antenna aimed at 5G applications. As the demand for high-speed wireless communication continues to surge with the advent of 5G networks, the development of antennas capable of supporting a wide range of frequencies becomes imperative.

The authors tackle this challenge by focusing on the creation of an antenna optimized for efficient operation across the diverse frequency bands allocated for 5G communication. Leveraging advanced optimization techniques and simulation-based analysis, they aim to achieve broadband performance while ensuring key antenna parameters such as gain, radiation pattern, and impedance matching are met.

The study likely delves into the intricate details of the antenna design methodology employed by the researchers. This may involve exploring innovative approaches to enhance bandwidth and efficiency, potentially through novel antenna structures or materials tailored specifically for 5G requirements. By systematically optimizing the antenna's design parameters, the authors strive to push the boundaries of current antenna technology to meet the stringent demands of 5G systems. The research represents a significant contribution to the field of antenna engineering, offering valuable insights and design strategies that could pave the way for the development of high-performance antennas crucial for the success of 5G networks.

[3]Y. Zhou et al.,2021 IEEE introduce a compact magneto-electric dipole antenna tailored for Ultra-Wideband (UWB) applications. Recognizing the increasing demand for efficient antennas capable of supporting wide bandwidths in UWB systems, the authors focus on designing a compact antenna solution that offers enhanced bandwidth performance. This research addresses the need for UWB antennas with improved frequency coverage, which is essential for applications such as high-speed data transmission, radar imaging, and wireless sensor networks.

The study likely presents innovative design methodologies employed by the researchers to achieve enhanced bandwidth while maintaining a compact form factor. This may involve optimization techniques applied to antenna geometries, feeding structures, or materials to maximize frequency coverage across the UWB spectrum. Through a combination of simulation-based analysis and experimental validation, the authors aim to demonstrate the effectiveness of their proposed antenna design in achieving the desired broadband performance.

By showcasing the compact magneto-electric dipole antenna's improved bandwidth capabilities in UWB applications, the research by Y. Zhou et al. provides valuable insights for advancing the field of UWB antenna design. Their findings contribute to the ongoing efforts in developing efficient UWB communication systems and devices, offering engineers and researchers a promising solution to meet the growing demands of modern wireless communication technologies

[4]J.-C. Chiu, S.-C. Hsiao, P.-K. Tseng, Y.-C. Lai, and C.-W. Huang 2020 IEEE microwave and wireless components letters are published and proposed work is an ultracompact low cost and performance rf package technique for WiFi FEM application.

With the advent of next-generation Wi-Fi technology, the demand for shrinking Wi-Fi front end module (FEM) product size is voracious. In this letter, a novel package technique called hot-via chip-scale package (HVCSP) is proposed.

HVCSP has benefits such as ultra small package size, low cost, bump-free, substrate free, and outstanding RF performance. In this letter, a 5-GHz Wi-Fi FEM using GaAs based Bi-HEMT technology and HVCSP is also demonstrated.

Due to the wire and lead frame-free structure, the package size can be further reduced by over 40% compared to the traditional QFN package. By employing a hot-via transformer structure, the measurement loss from chip to package is below -0.5 dB from 0 to 67 GHz. With these advantages, HVCSP is suitable for Wi-Fi FEM applications perfectly.

[5] V.P. Sarin, M.S. Nishamoi, C. Tony, C, K, Aanand, P, Mohanan, and K. Vasudevan," A wideband stacked offset microstrip antenna with improved gain and low cross polaraization," IEEE Trans.Antennas Propag., vol.59 A broadband printed microstrip antenna having cross polarization level>15dB with improved gain in the entire frequency band is presented. principle of stacking is implemented on a strip loaded slotted broadband patch antenna for enhancing the gain without affecting the broad band impedance matching characteristics and offsetting the position of the upper patch exists a low resistance which enhances the bandwidth further.

CHAPTER 3
PROPOSED SYSTEM

3.1 INTRODUCTION

3.1.1 Need of Antennas

In each and every case, the transmitters and receivers involved require antennas, even if some are hidden like inside laptop computers equipped with WiFi, or inside radio. According to the IEEE standards definition of terms for antennas, antenna is basically defined as the means of transmitting and receiving radio waves. It can also be defined as the transitional structure between the free space and the guiding space.

Antennas required by any radio receiver or transmitter to couple its electrical connection to the electromagnetic field. Radio waves are electromagnetic waves which carry signals through the air or through space, at the speed of light. Radio transmitters and receivers are used to convey signals/ information in the systems including broadcast radio, Wi-Fi, point to point communication links and many remote controlled devices.

3.1.2 Types of Antennas

Antennas are classified into many types which are described below:

On the basis of radiation

Omni-directional antenna: Also called as weakly directional antennas which radiate and receive more or less in all directions.

Directional antenna: Also called as beam antennas which radiate and receive in a particular direction. A directional antenna is intended to maximize its coupling to the electromagnetic field in the direction of the other station or to cover a particular sector.

On the basis of Aperture

Wire Antennas: These types of antennas are familiar to layman as the antennas are seen everywhere like on automobiles, buildings, and aircrafts.

Aperture Antennas: These antennas are more familiar to the lay man today than in the past because of the increasing demand for more sophisticated form of antennas and also for utilization of higher frequencies. These are more useful in spacecraft and aircraft applications as they can be easily mounted on them.

Array Antennas: To get the required radiation characteristics, which is not possible with single antenna, then an aggregate of radiating elements called array are used. The arrangement of the arrays should be such that the radiation adds up to give maximum radiation in a particular direction or directions and minimum in other directions.

On the basis of Polarization:
Linearly polarized antenna: If the antenna is transmitting /receiving in the vertical E direction then it is called vertically polarized antenna. If the antenna is transmitting/receiving in the horizontal E direction then it is called horizontally polarized antenna.

Circularly polarized antenna: If the antenna is able to transmit/receive E field vectors of any orientation, then antenna is said to be circularly polarized antenna. The major requirement in the present wireless world is to have the size of antenna as small as possible, so out the available structures when application in terms of WLAN is considered; the microstrip antennas serve as the most optimum choice.

ME-DIPOLE antenna: A magneto-electric dipole (MED) antenna is a type of antenna that utilizes both electric and magnetic dipoles for efficient radiation and reception of electromagnetic waves. Unlike traditional antennas that rely solely on either electric or magnetic fields for operation, MED antennas combine both mechanisms, resulting in improved performance characteristics such as broader bandwidth and higher efficiency. The design of a MED antenna typically involves integrating electric and magnetic dipole elements in close proximity, allowing for effective coupling between the electric and magnetic fields. This coupling enhances the antenna's radiation properties, making it well-suited for various applications including wireless communication, radar systems, and sensing technologies.

One advantage of MED antennas is their ability to operate across a wide range of frequencies, from radio frequencies to microwave frequencies and beyond. This versatility makes them valuable for applications requiring multi-band or broadband capabilities.

Moreover, MED antennas exhibit polarization diversity, meaning they can transmit and receive both linearly and circularly polarized signals. This feature is advantageous in scenarios where polarization mismatch can degrade signal quality, such as in urban environments or non-line-of-sight communications.

3.1.3 Antenna parameters

[1] Antenna gain

Gain is a measure of the ability of the antenna to direct the input power into radiation in a particular direction and is measured at the peak radiation intensity. Consider the power density radiated by an isotropic antenna with 2 input power P0 at a distance R which is given by S= P0/4πR. An isotropic antenna radiates equally in all directions, and its radiated power density S is found by dividing the radiated power by the area of the sphere.

An isotropic radiator is considered to be 100% efficient. The gain of an actual antenna increases the power density in the direction of the peak radiation. Gain is achieved by directing the radiation away from other parts of the radiation sphere. In general, gain is defined as the gain-biased pattern of the antenna.

$$G = 4\pi A/\lambda^{\wedge}2$$

[2] Antenna efficiency

The surface integral of the radiation intensity over the radiation sphere divided by the input power P0 is a measure of the relative power radiated by the antenna, or the antenna efficiency.

Efficiency = (Gain / Directivity) * 100

Where Pr is the radiated power. Material losses in the antenna or reflected power due to poor impedance match reduce the radiated power.

[3] Effective area

Antennas capture power from passing waves and deliver some of it to the terminals. Given the power density of the incident wave and the effective area of the antenna, the power delivered to the terminals is the product.

$$A = \varepsilon eff * (L * W) / (2 * \lambda^2)$$

For an aperture antenna such as a horn, parabolic reflector, or flat-plate array, effective area is physical area multiplied by aperture efficiency. In general,losses due to material, distribution, and mismatch reduce the ratio of the effective area to the physical area. Typical estimated aperture efficiency for a parabolic reflector is 55%. Even antennas with infinitesimal physical areas, such as dipoles, have effective areas because they remove power from passing waves. The effective area, also known as the effective aperture, of an antenna refers to the hypothetical area that represents the ability of the antenna to receive or transmit electromagnetic energy. It is a measure of the antenna's efficiency in capturing or radiating power.

[4] Directivity

Directivity is a measure of the concentration of radiation in the direction of the maximum.

Directivity = (4π × Maximum Radiation Intensity) / Total Radiated Power

Directivity and gain differ only by the efficiency, but directivity is easily estimated from patterns. Gain—directivity times efficiency—must be measured. The average radiation intensity can be found from a surface integral over the radiation sphere of the radiation intensity divided by 4π, the area of the sphere in steradians:

$$\text{average radiation intensity} = \frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi} U(\theta,\phi)\sin\theta\, d\theta\, d\phi = U_0$$

This is the radiated power divided by the area of a unit sphere. The radiation intensity U(θ,φ) separates into a sum of co- and cross-polarization components:

$$U_0 = \frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi}[U_C(\theta,\phi) + U_\times(\theta,\phi)]\sin\theta\, d\theta\, d\phi$$

Both co- and cross-polarization directivities can be defined:

[5] Path loss

We combine the gain of the transmitting antenna with the effective area of the receiving antenna to determine delivered power and path loss. The power density at the receiving antenna is given by equation and the received power is given by equation. By combining the two, we obtain the path loss as given below.

$$\frac{P_d}{P_t} = \frac{A_2 G_1(\theta,\phi)}{4\pi R^2}$$

Antenna 1 transmits, and antenna 2 receives. If the materials in the antennas are linear and isotropic, the transmitting and receiving patterns are identical . When we consider antenna 2 as the transmitting antenna and antenna 1 as the receiving antenna, the path loss is

$$\frac{P_d}{P_t} = \frac{A_1 G_2(\theta,\phi)}{4\pi R^2}$$

We make quick evaluations of path loss for various units of distance R and for frequency fin megahertz using the formula

$$\text{path loss(dB)} = K_U + 20\log(fR) - G_1(\text{dB}) - G_2(\text{dB})$$

[6] Input impedance

The input impedance of an antenna is defined as the impedance presented by an antenna at its terminals or the ratio of the voltage to the current at the pair of terminals or the ratio of the appropriate components of the electric to magnetic fields at a point‖. Hence the impedance of the antenna can be written as given below.

$$Z_{in} = R_{in} + jX_{in}$$

Where Z_{in} is the antenna impedance at the terminals
R_{in} is the antenna resistance at the terminals

X_{in} is the antenna reactance at the terminals. The imaginary part, X_{in} of the input impedance represents the power stored in the near field of the antenna. The resistive part, R_{in} of the input impedance consists of two components, the radiation resistance R_r and the loss resistance RL. The power associated with the radiation resistance is the power actually radiated by the antenna, while the power dissipated in the loss resistance is lost as heat in the antenna itself due to dielectric or conducting losses.

[7] Return loss

It is a parameter which indicates the amount of power that is ―lost‖ to the load and does not return as a reflection. Hence the RL is a parameter to indicate how well the matching between the transmitter and antenna has taken place. Simply put it is the S11 of an antenna. A graph of s11 of an antenna vs frequency is called its return loss curve. For optimum working such a graph must show a dip at the operating frequency and have a minimum dB value at this frequency.

[8] Radiation pattern

The radiation pattern of an antenna is a plot of the far-field radiation properties of an antenna as a function of the spatial co-ordinates which are specified by the elevation angle (θ) and the azimuth angle (φ). More specifically it is a plot of the power radiated from an antenna per unit solid angle which is nothing but the radiation intensity. It can be plotted as a 3D graph or as a 2D polar or Cartesian slice of this 3D graph. It is an extremely parameter as it shows the antenna ‘s directivity as well as gain at various points in space.

Radiation patterns are commonly used in the field of telecommunications, particularly in antenna engineering. They help determine the coverage area, gain, and directivity of an antenna, which are essential for optimizing wireless communication systems.

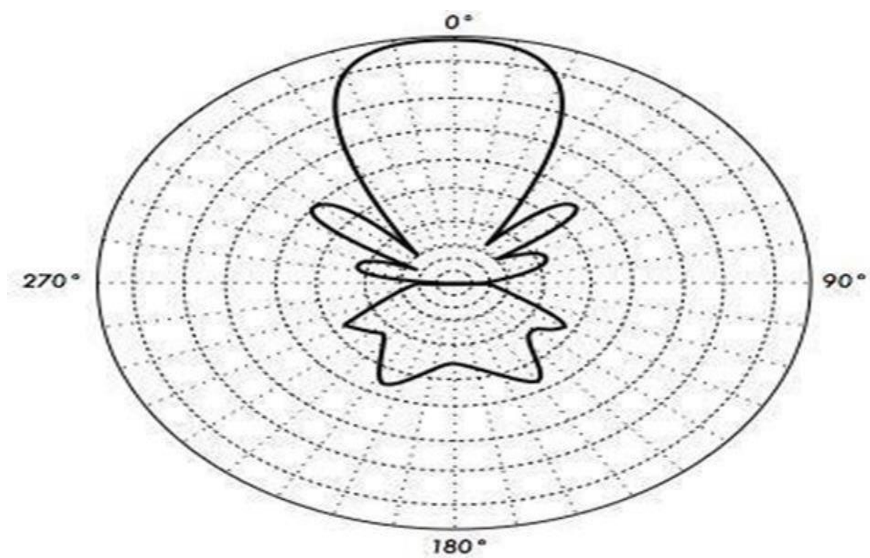


Fig 3.1a: Radiation pattern

[9] Beam width

Beam width of an antenna is easily determined from its 2D radiation pattern and is also a very important parameter. Beam width is the angular separation of the half-power points of the radiated pattern.

[10] Polarization

Polarization is defined as the orientation of the electric field of an electromagnetic wave. Polarization is in general described by an ellipse. Two special cases of elliptical polarization are linear polarization and circular polarization.

The initial polarization of a radio wave is determined by the antenna. With linear polarization the electric field vector stays in the same plane all the time.

Vertically polarized radiation is somewhat less affected by reflections over the transmission path. Omni directional antennas always have vertical polarization. With horizontal polarization, such reflections cause variations in received signal strength. Horizontal antennas are less likely to pick up man-made interference, which ordinarily is vertically polarized.

In circular polarization the electric field vector appears to be rotating with circular motion about the direction of propagation, making one full turn for each RF cycle. This rotation may be right hand or left hand. Choice of polarization is one of the design choices available to the RF system designer

Magneto-electric dipole antennas combine electric and magnetic dipole radiators to achieve high performance and polarization diversity. These antennas consist of a loop (magnetic dipole) and a pair of crossed dipoles (electric dipole). The loop generates a magnetic field, while the crossed dipoles produce an electric field, resulting in improved impedance matching and a wider bandwidth.

The combined radiation pattern from the magnetic and electric dipoles provides high gain and low cross-polarization. The antenna can achieve different types of polarization, such as linear, circular, or elliptical, depending on the orientation and excitation of the electric and magnetic dipoles. By adjusting the phase and amplitude of the supplied signals, polarization can be controlled to meet specific requirements.

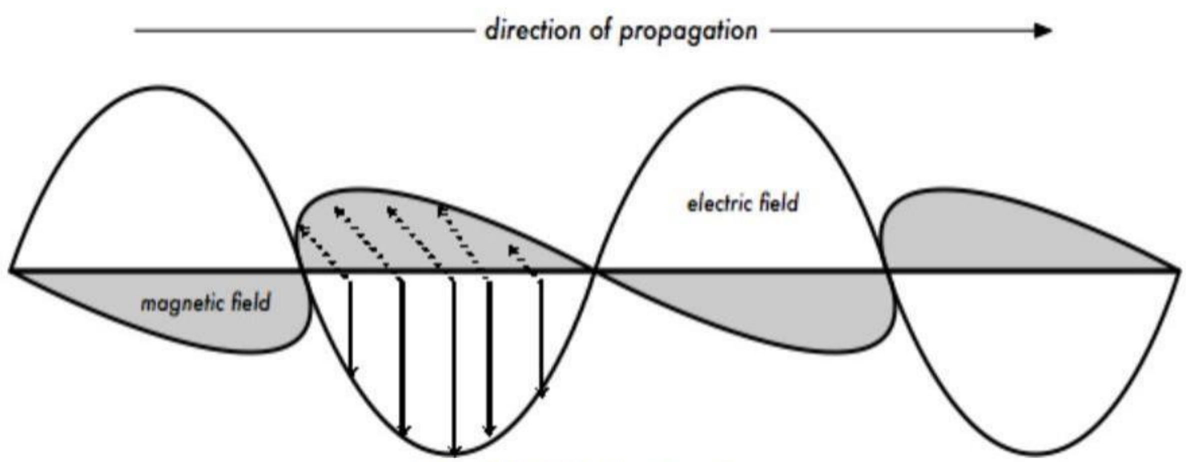


Fig 3.1 b: Polarization

Magneto-electric dipole antennas are versatile and suitable for applications in wireless communications, radar, and satellite systems due to their ability to deliver flexible polarization and consistent performance across various conditions.

3.2 BLOCK DIAGRAM

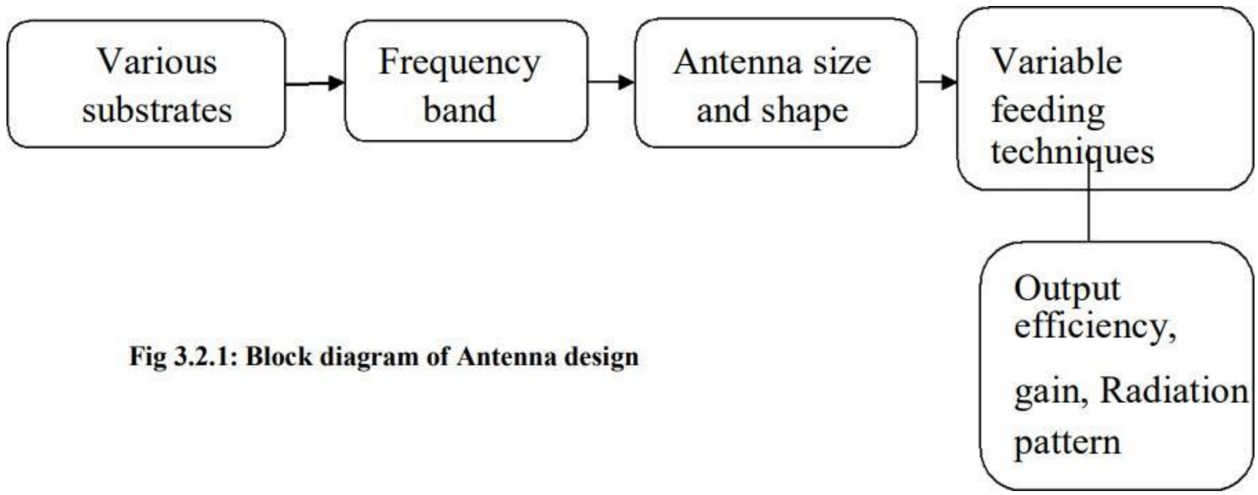


Fig 3.2.1: Block diagram of Antenna design

Various Substrates :

[1] Raio_CaixaRadiacao

[2] Vacuum

The Raio_CaixaRadiacao substrate is a metal-based copper clad laminate with very good heat dissipation function. Generally, a single panel is mainly composed of a three-layer structure, which is a circuit layer (copper foil), an insulating layer and a metal base layer and also it is lightweight and strong material.

3.2.1 Source selection

Substrate : Raio_CaixaRadiacao

Thickness : 2mm

Permittivity :1.0-1.7

Loss tangent :0.01-0.03

Raio_CaixaRadiacao is often preferred as a substrate for various applications due to its lightweight nature, high strength-to-weight ratio, corrosion resistance, and conductivity properties.

It's widely used in industries like aerospace, automotive, and electronics for these reasons.

3.2.2 Frequency band

ME-dipole antennas are designed to operate within a specific range of frequencies, such as UHF (Ultra High Frequency) or VHF (Very High Frequency). The exact frequency band depends on factors such as the antenna's dimensions, materials, and surrounding environment. f=c/length*permittivity $\varepsilon = (\varepsilon r+1)/2$ $\varepsilon r=1.7$.

3.2.3 Coefficient Calculation

Radiation pattern

It is defined for large distances from the antenna, where the spatials (angular) distribution of the radiated power does not depend on the distance from the radiation source. It is usually different for different frequencies and different polarizations of radio wave radiated/ received.

Return loss

Return loss is the loss of power in the signal returned/reflected by a discontinuity in a transmission line or optical fiber. This discontinuity can be a mismatch with the terminating load or with a device inserted in the line. It is usually expressed as a ratio in decibels (dB).

$$RL(\mathrm{dB}) = 10 \log_{10} \frac{P_\mathrm{i}}{P_\mathrm{r}}$$

Where RL(dB) is the return loss in dB,

Pi is the incident power

Pr is the reflected power.

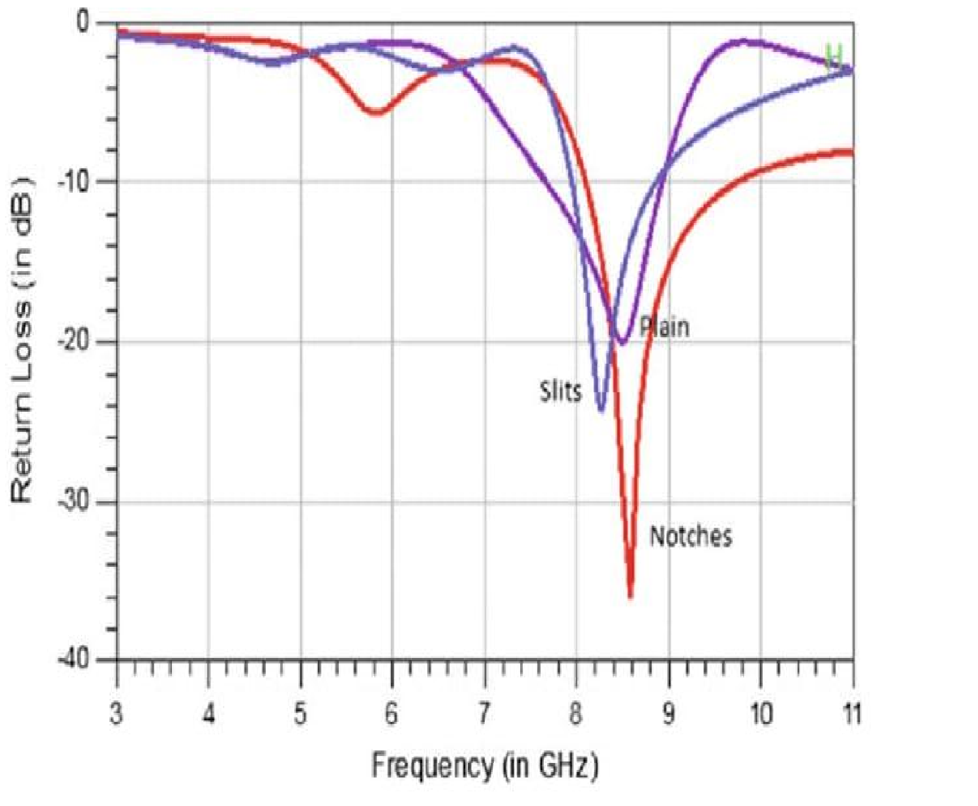


Fig 3.2.2: Return loss

3.3 FEEDING TECHNIQUES

ME-dipole antennas can be fed using different methods. These methods are classified into two categories;

- Contacting
- Non-contacting

The contacting method involves the process where the RF power is fed directly to the radiator using a connecting element such as a Γ line. In the non contacting method, this consists of an electromagnetic field coupling done to transfer power between the Γ line and the radiator.

There are many methods of feeding a ME-dipole antenna. Although, the popular four methods include:

- Direct feeding
- Aperture Coupling
- Proximity Coupling
- Hybrid Coupling

The architecture of the antenna is radiating from one side of the substrate, so it is easy to feed it from the other side (the ground plane), or from the side of the element.

3.3.1Direct Feeding:

In this method, the signal is directly applied to the antenna element without any additional components. It's straightforward and commonly used for simple antenna designs. By connecting the feedline directly to the antenna elements, such as the two perpendicular dipoles, the antenna can achieve improved performance characteristics.

This direct connection can enhance the antenna's bandwidth and radiation efficiency, making it an attractive option for various wireless communication applications where simplicity and performance are key considerations.

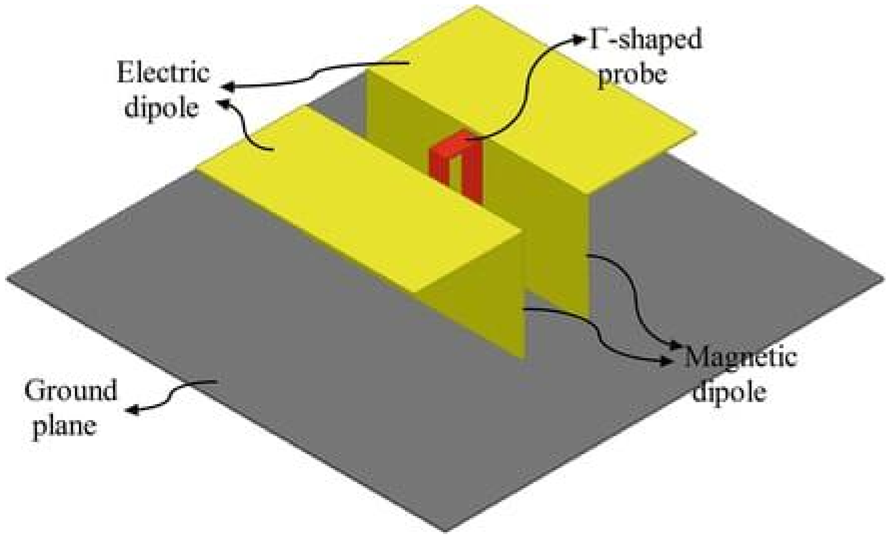


Fig 3.3.1: Uppercase gamma feedline Technique

The impedance of the director is given by:

$$Z_{\propto} = 90 \frac{\varepsilon_r^2}{\varepsilon_r - 1}\left(\frac{L}{W}\right)^2$$

The width of the transition element is derived from:

$$Z_T = \frac{60}{\sqrt{\varepsilon_r}} ln\left(\frac{8d}{W_T} + \frac{W_T}{4d}\right)$$

The impedance of the ME-dipole feed is determined using the equation below:

$$Z_0 = \frac{120\pi}{\sqrt{\varepsilon_{reff}\left(1.393 + \frac{W}{h} + \frac{2}{3}ln\left(\frac{W}{h} + 1.444\right)\right)}}$$

The length of the feedline can be found using:

$$R_{In(x=0)} = cos^2\left(\frac{\pi}{L}x_0\right)$$

3.3.2Aperture Coupling:

The signal is coupled to the antenna through an aperture in a conducting surface. This technique allows for better control over impedance matching and radiation pattern shaping.

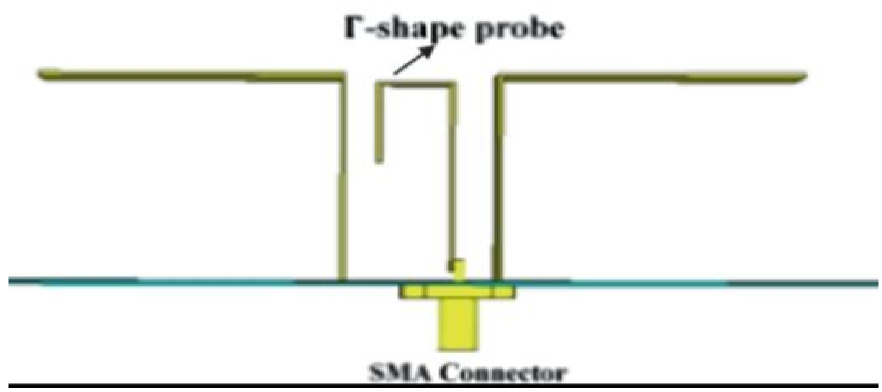


Fig 3.3.2 Uppercase gamma connected by SMA connector

3.3.3Proximity Coupling:

This technique involves placing the feed element close to the antenna structure without direct physical contact. It enables efficient energy transfer while maintaining some isolation between the feed circuit and the antenna.

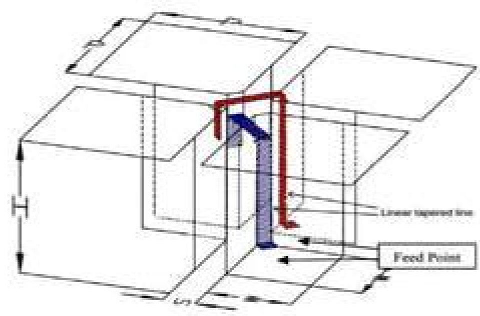


Fig 3.3.3 Geometry of uppercase gamma shaped feed

Proximity coupling of magneto-electric dipole antennas involves positioning two antennas close to each other to exploit their mutual interaction for enhanced performance. These antennas are characterized by their ability to radiate both electric and magnetic fields simultaneously, offering advantages in compactness and bandwidth.

By placing them in close proximity, their near fields interact, enabling efficient energy transfer and signal reception. This coupling effect enables various applications such as wireless power transfer, near-field communication, and sensing systems. It's particularly useful in situations where conventional antennas face limitations due to size constraints or environmental factors.

However, careful design and positioning are crucial to optimize coupling efficiency and minimize interference. Through proximity coupling, magneto-electric dipole antennas offer a promising solution for diverse wireless communication and sensing applications, paving the way for more efficient and compact antenna systems in various domains.

Hybrid Couplings:

Hybrid methods combine two or more of the above techniques to achieve specific performance goals. For example, a combination of direct feeding and aperture coupling might be used to optimize both impedance matching and radiation pattern characteristics.

3.4 Method of Analysis :

There are many methods of ME-dipole antenna analysis; the preferred models for the analysis of Magneto electric dipole antennas are the transmission line model and the cavity model.

The transmission line model involves where we assume that the patch is a transmission line or part of a transmission line. The transmission line model is very simple to study but it is less accurate.

The cavity model is accurate and provides good physical insight but is complex in nature; it involves the assumption that the patch is a dielectric-loaded cavity.

3.4.1 Transmission Line Model:

The transmission line method is an easy way of studying the ME-dipole antenna. This involves the representation of the ME-dipole antenna using two slots of width W and height h, separated by a low-impedance transmission line of length L. The ME-dipole is a non-homogeneous line of two dielectrics, typically the substrate and air.

The study of the ME-dipole line involves a wider transmission line ($w/h \gg 1$ and > 1) .

The approximation occurs initially to assume the thickness of the conductor that forms the line has no effect on our calculations, because it is very thin comparing with the substrate h, (h >> t); therefore empirical formulas are used depending only on the line dimensions: The width W, the length L, the height h, and the dielectric constant of the substrate.

The impedance of the ME-dipole is determined using:

$$Z_0 = \frac{120\pi}{\sqrt{\varepsilon_{reff}\left(1.393+\frac{W}{h}+\frac{2}{3}ln\left(\frac{W}{h}+1.444\right)\right)}}$$

The width of the ME-dipole feedline is derived using the equation below :

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}}$$

Fig 3.4.1 : Electric field lines

From Figure 3.4.1 b, it is seen that most of the electric field lines reside in the substrate and parts of some lines in air. As a result, this transmission line cannot support pure transverse-electric-magnetic (TEM) mode of transmission, since there is different phase velocities in air and the substrate. Therefore, the dominant mode of propagation would be the quasi-TEM mode.

Hence, an effective dielectric constant (Ɛ $_{reff}$) must be obtained in order to account for the fringing and the wave propagation in the line, leading to the value of slightly less than because the fringing fields around the periphery of the patch are not confined in the dielectric substrate but are also spread in the air. The Effective dielectric constant is given as:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\,\frac{h}{W}\right]^{\frac{1}{2}}$$

Where = Effective dielectric constant, = Dielectric constant of the substrate , = Height of the dielectric substrate, = Width of the patch

The ME-Dipole antenna is longer than its physical dimensions because of the effect of fringing. The effective length is therefore different from the physical length by ΔL. The fringing fields along the width are modeled as the radiating slots.

The extension of the length of patch is determined using the equation by Hammers tad as:

$$\Delta L / h = 0.412\left[\frac{(\varepsilon_r^{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_r^{eff}-0.258)\left(\frac{W}{h}+0.8\right)}\right]$$

This extension of length expresses it as a function of the ratio / and .

To calculate the effective length of the patch :

$$L_{eff} = L + 2\Delta L$$

Therefore the Actual length of the patch L is:

$$L = L_{eff} - 2\Delta L$$

For a given resonance frequency 0, the effective length given as:

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}}$$

3.4.2 Cavity method:

The cavity model used in analyzing the ME-dipole antennas is based on the assumption that the region between the ME-dipole and ground plane has a resonance cavity bounded by ceiling and floor of electric conductors and magnetic walls along the edge of the conductor.

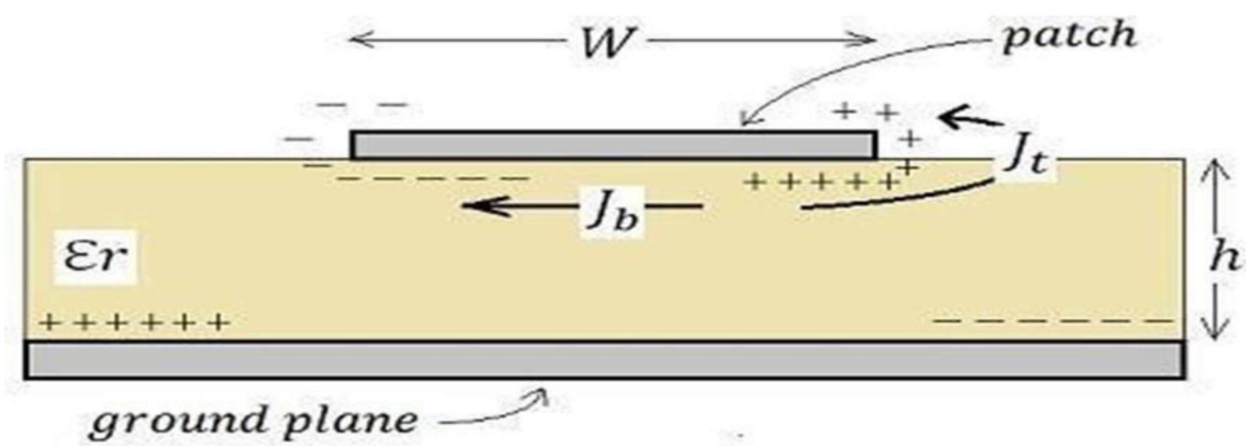


Fig 3.4.2: Charge distribution and current density creation on the ME-dipole patch.

This is used to study the mechanism of the cavity. This involves the process where the ME-dipole patch is provided power when connected to a microwave source; charge distribution is created and seen on the upper and lower planes (surface of the patch and the bottom of the ground plane) of the antenna.

The charge distribution is controlled by two mechanism; an attractive and repulsive mechanism.

The attractive mechanism consist of a force between the opposite charges on the patch and on the ground plane, it creates a current density inside the dielectric at the bottom of the patch, which helps in keeping the charge concentration intact at the bottom of the patch.

The repulsive mechanism is between the like charges on the bottom surface of the patch, which tend to push the charges from the bottom of the patch around the edge of the patch to the top of the patch, this will create the current density . As a result of this charge movement, currents flow at the top and bottom surface of the patch.

In the case of ME-dipole antennas W >> h the attractive mechanism dominates and at charges concentration will within the dielectric under the patch, and the current flow around the edge can be neglected, because it decreases with corresponding decrease in the ratio of the height to width. ―This would allow the walls to be modelled as a perfect magnetic conducting surface which would not disturb the magnetic field and in turns the electric field distribution beneath the patch in an ideal environment‖. This good approximation to the cavity model leads us to deal with the side walls as perfect magnetic conducting walls.

3.4.3 The Ground Plane:
The ground plane is infinite in size as for a monopole antenna, but in reality this is not applied easily, besides a small size of ground plane is required. The length of the ground plane should be at least one wavelength (i.e. the length of the patch is equal or less than half wavelength (≤ 02). Therefore the ground plane will extend 4 from edge of the patch

$$\lambda_0 = \frac{c}{f_r}$$

Where 0 is the wavelength in free space.

C is the speed of light in free space is resonance frequency.

The effective wavelength of a substrate is determined using the equation below:

$$\lambda_{eff} = \frac{c}{f_r}\sqrt{\varepsilon_{reff}}$$

Where, C is the dielectric constant in the substrate. The width if the patch W must be less than the wavelength in the dielectric substrate in order for the higher-order modes not to be excited.

3.5 Flowchart

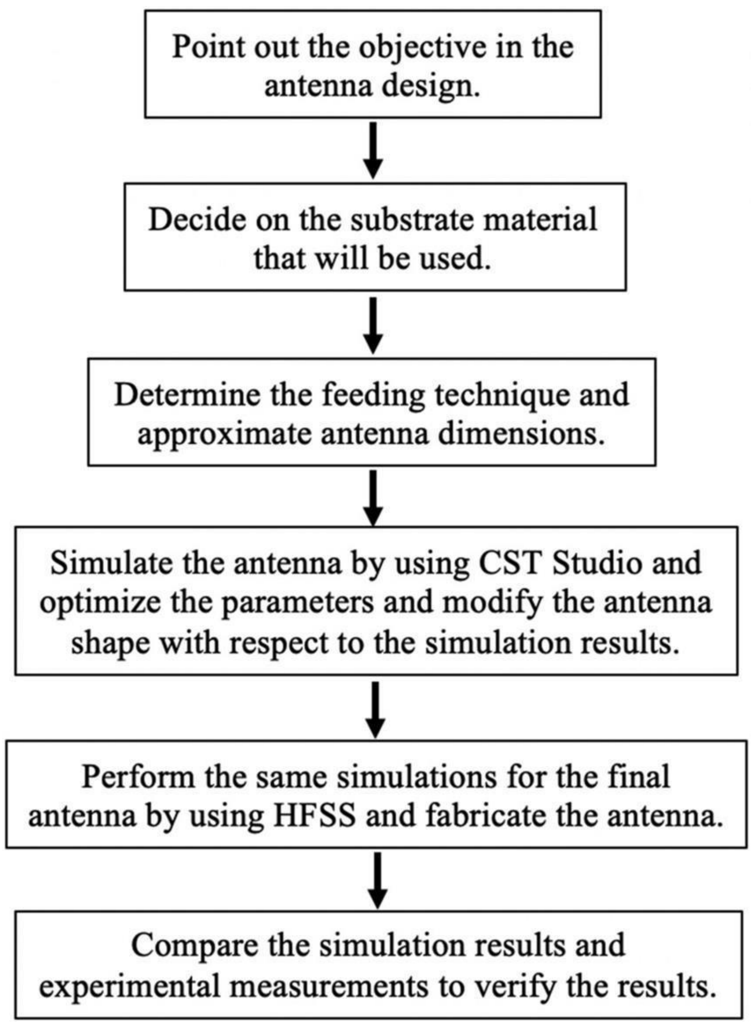


Fig 3.5: Flow chart of antenna design

The flow of processes takes place in antenna design is of 6 steps.

Step1: The frequency bands in which in our designing antenna have to work and the materials in which our antenna have to be fabricated and the properties of materials are determined.

Step 2: The design measurements are made by considering the resonant frequencies of each band. The length and widths of the stubs of antenna are calculated by using the frequency band formula. The mesh array design is made with the various stubbed arms.

Step 3: The antenna is designed by any one type of Electromagnetic simulator. The antenna simulator considered mainly is HFSS software. The mesh array model is implemented in this software.

Step 4: The antenna is simulated for obtaining the desired performance. If the desired results are obtained we go for the further processing. Otherwise the length/frequency of antenna is optimized and again simulated to reach the desired output.

Step 5: In this step the stubs and the antenna is made to obtain the multi-band operation which has to operate in the more than one band in single antenna.

Step 6: In case, the desired multi-band operation is not obtained in graphical simulation, the antenna once again go for optimization of length/frequency. If the satisfied graphical plots are not obtained, we go for optimization otherwise the antenna is fabricated and tested by using Vector Network Analyzer.

3.6 SOFTWARE DESCRIPTION

Simulator Used	: EM Stimulator
Software Used	: Ansys HFSS
Platform Used	: Windows
Package	: HFSS 2013 Edition

3.6.1 Tool analysis

The adaptive solution process is the method by which HFSS guarantees that a final answer to a given EM problem is the correct answer. It is a necessary part of the overall solution process and is the key reason why a user can have extreme confidence in HFSS's accuracy.

3.6.2 Work flow of HFSS:

There are six main steps to creating and solving a proper CST simulation.

They are:

1. Create model/geometry
2. Assign parameters
3. Built up structure
4. Set up the solution
5. Solve
6. Post-process the results

Every HFSS simulation will involve, to some degree, all six of the above steps. While it is not necessary to follow these steps in exact order, it is good modeling practice to follow them in a consistent model-to-model manner. HFSS High frequency structure simulator is a comprehensive software package for electromagnetic simulation, which includes tools for designing, analyzing, and optimizing antennas and other electromagnetic systems. It allows users to simulate and visualize the radiation pattern of an antenna by solving Maxwell's equations numerically. This enables engineers to assess the antenna's behavior, such as its coverage area, beam shape, and side lobe levels, and make informed decisions during the design process.

Step One

The initial task in creating an HFSS model consists of the creation of the physical model that a user wishes to analyse. This model creation can be done within HFSS using the 3D modeler. The 3D modeler is fully parametric and will allow a user to create a structure that is variable with regard to geometric dimensions and material properties. A parametric structure, therefore, is very useful when final dimensions are not known or design is to be tuned.‖ Alternatively, a user can import 3D structures from mechanical drawing packages, such as Solid Works®, Pro/E® or AutoCAD®. However, imported structures do not retain any ―history‖ of how they were created, so they will not be parameterizable upon import. If parameterization of the structure is desired, a user will need to manually modify the imported geometry so that parameterization is possible.

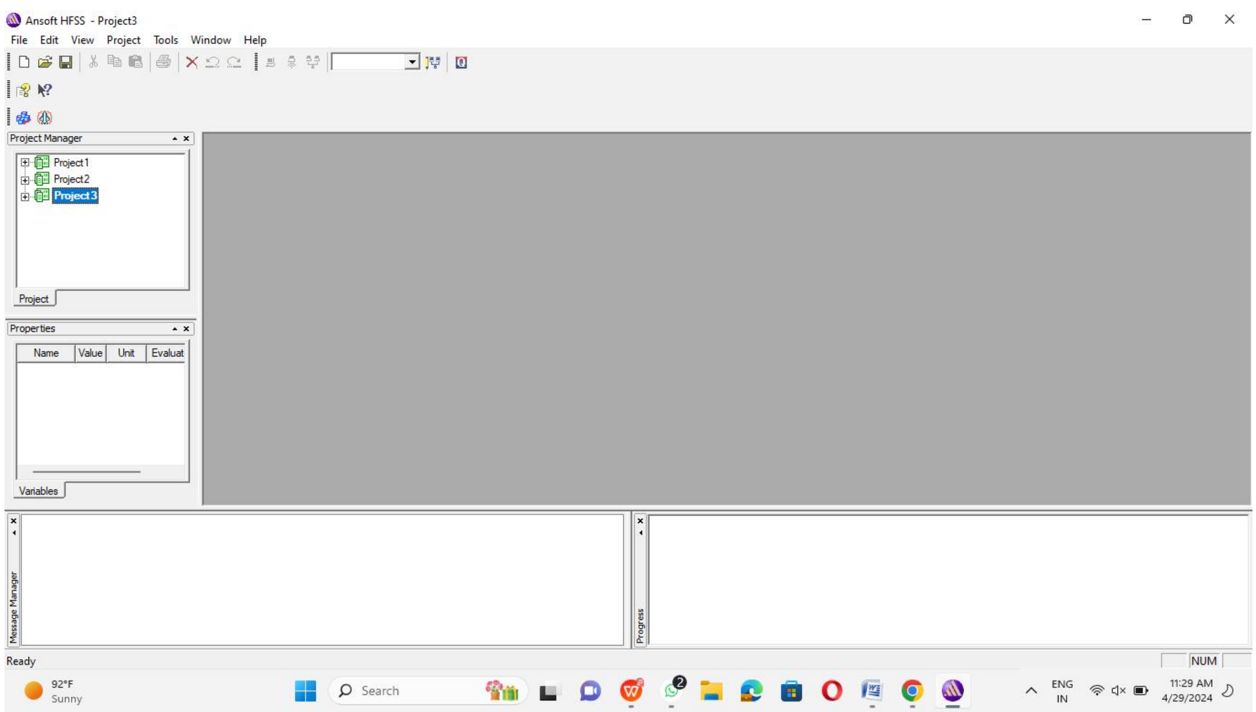


Fig 3.6.2.1

Step Two

In this step that axis has to be set. The assignment of parameters generally is done next. Parameters are applied to specifically created 2D (sheet) objects or specific surfaces of 3D objects. Parameters have a direct impact on the solutions that HFSS provides; therefore, users are encouraged to closely review the section on parameters in this document. Also it involves defining variables that can be used to control various aspects of your design or simulation. Parameters allow you to easily modify and update specific values throughout your project without manually changing each occurrence.

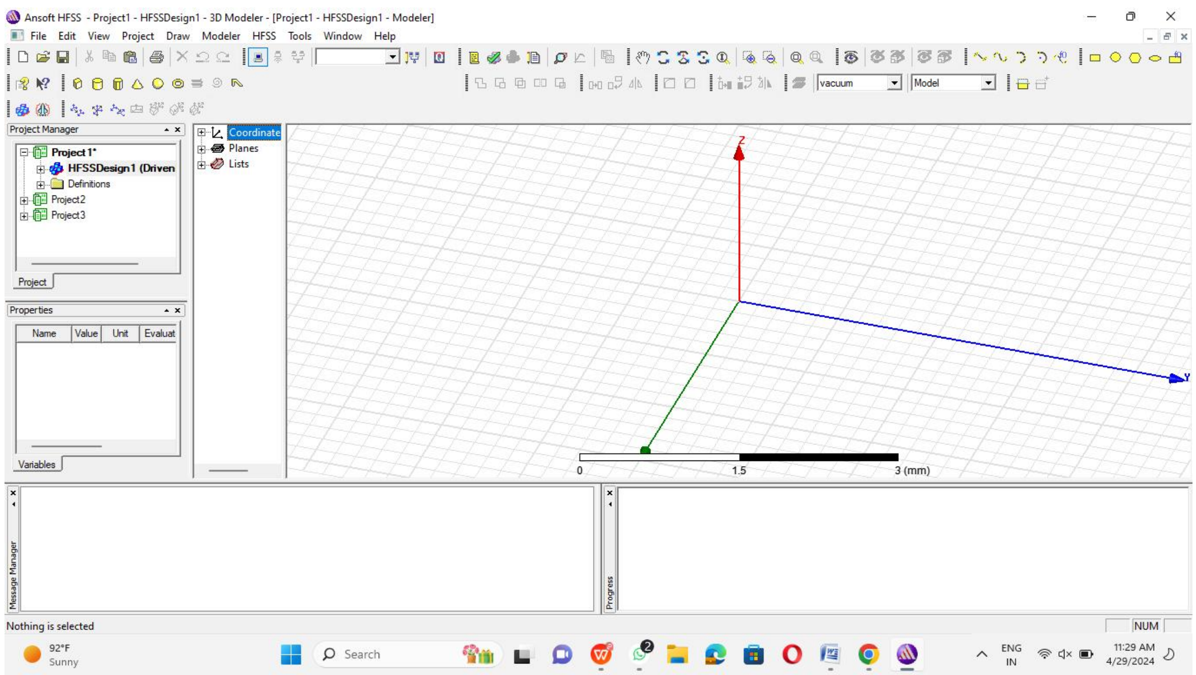


Fig 3.6.2.2

Step Three

The parameters have been assigned, the structure of antenna is designed(or ports) by the help of parameters applied. As with parameters, the structure have a direct impact on the quality of the results that HFSS will yield for a given model. Because of this, users are again encouraged to closely review the section on structures in this document.

While the proper creation and use of excitations is important to obtaining the most accurate HFSS results, there are several convenient rules of thumb that a user can follow. These rules are described in the excitations section.

This step gives adding data table for antenna.

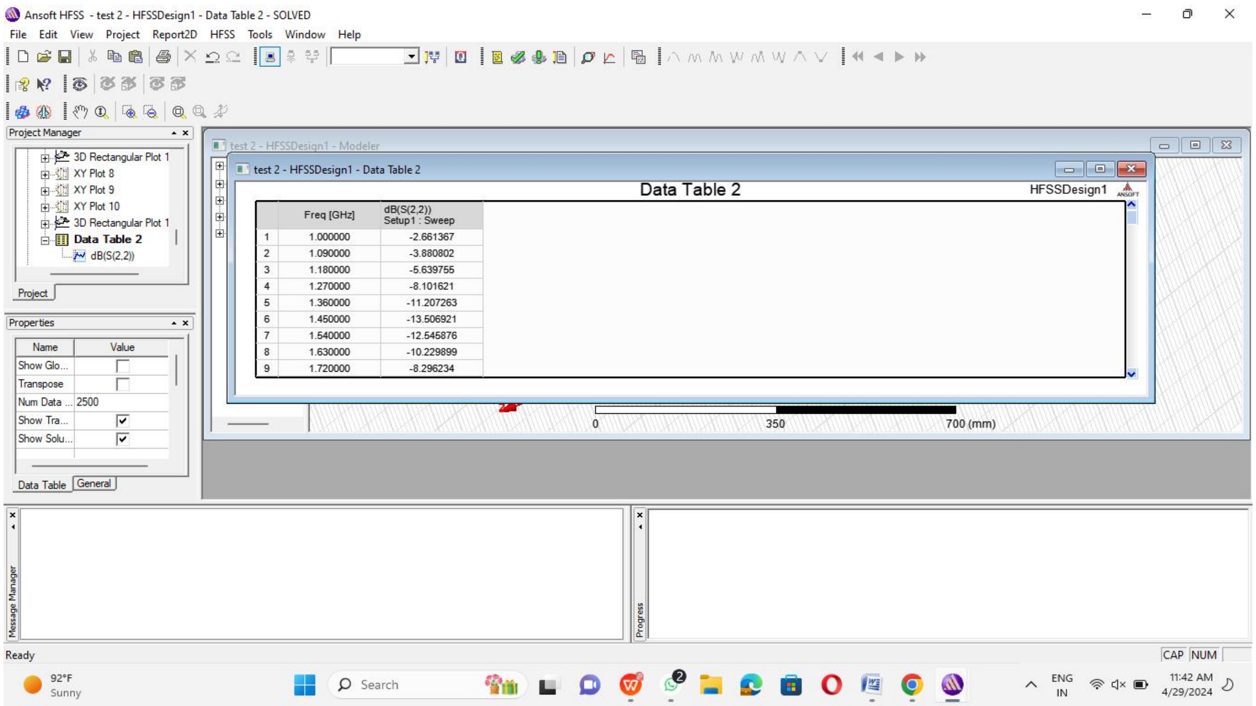


fig 3.6.2.3

Step Four

Once parameters and the structure have been created, the next step is to create a solution setup. During this step, a user will select a solution frequency, the desired convergence criteria, the maximum number of adaptive steps to perform,frequency band over which solutions are desired, and what particular solution and frequency sweep methodology to use.

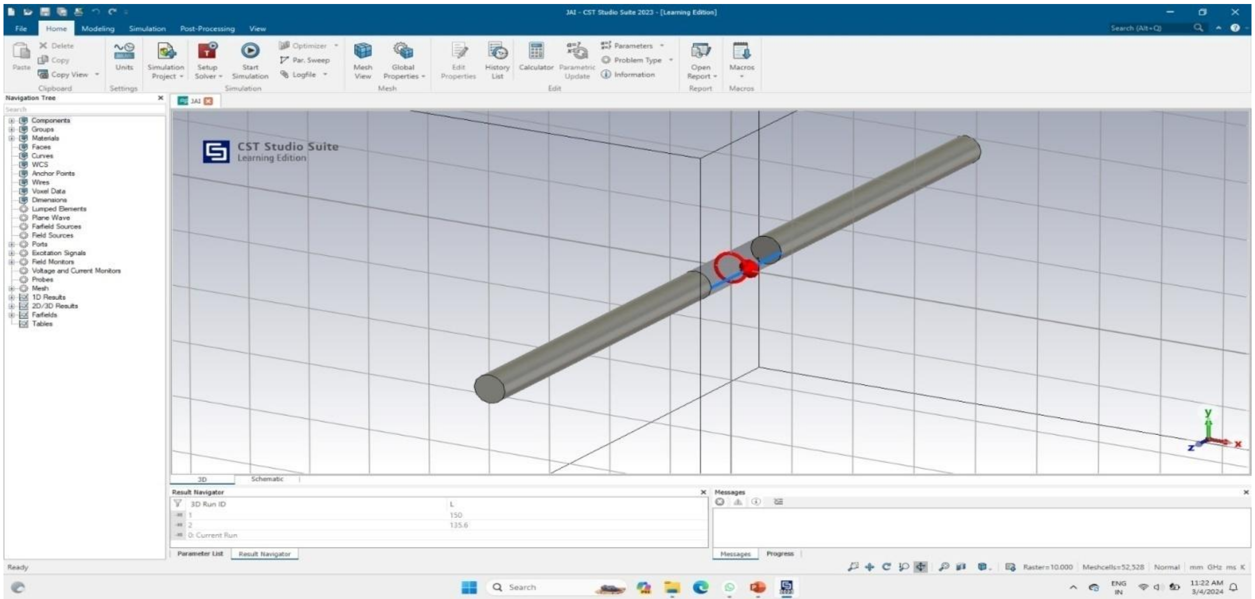


fig 3.6.2.4

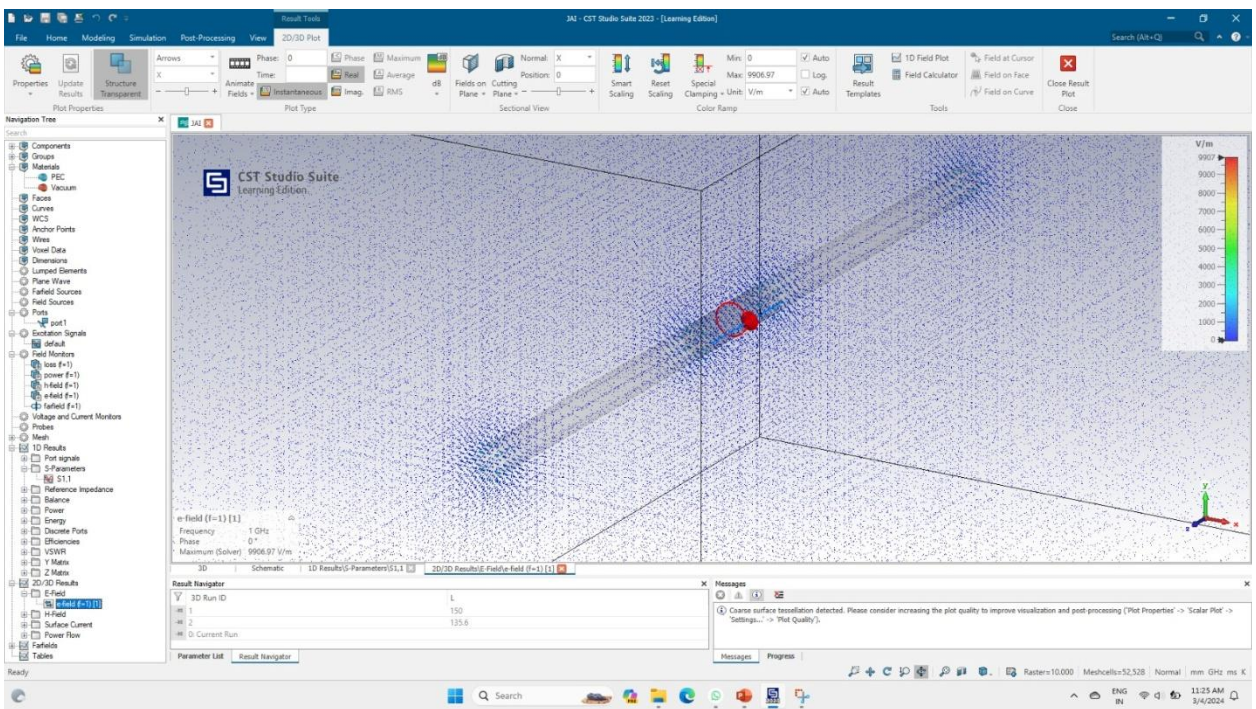


fig 3.6.2.5

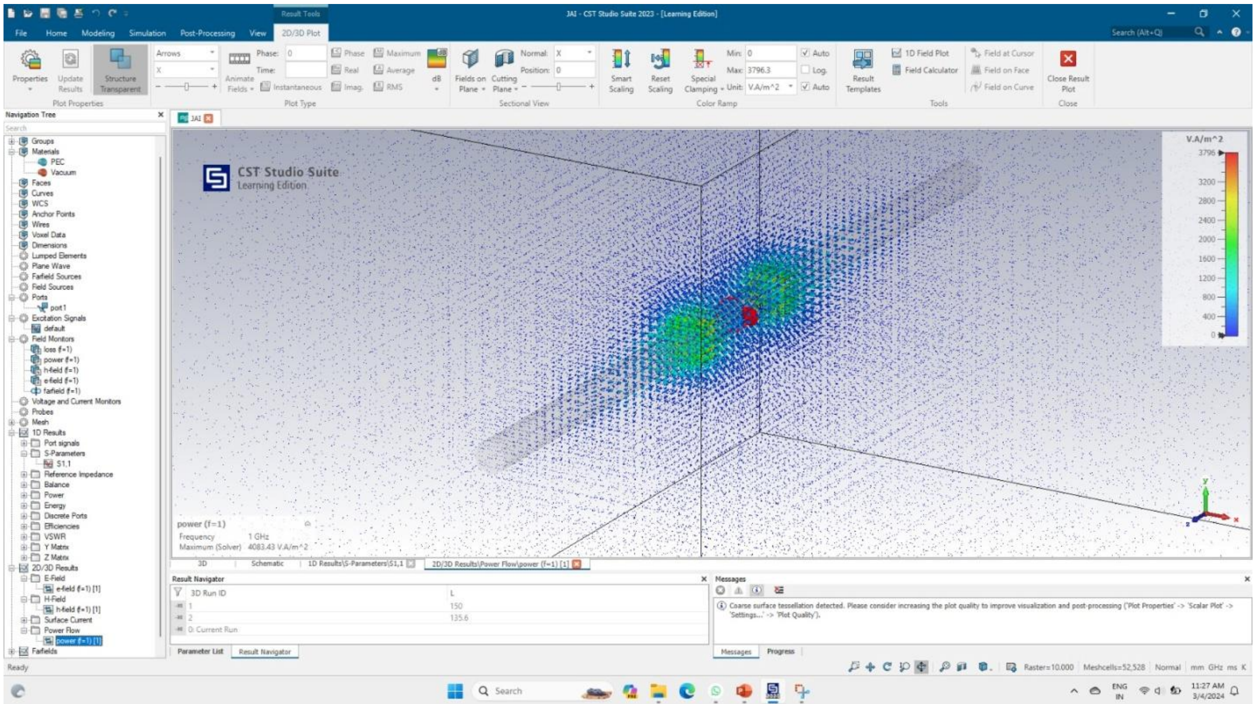


fig 3.6.2.6

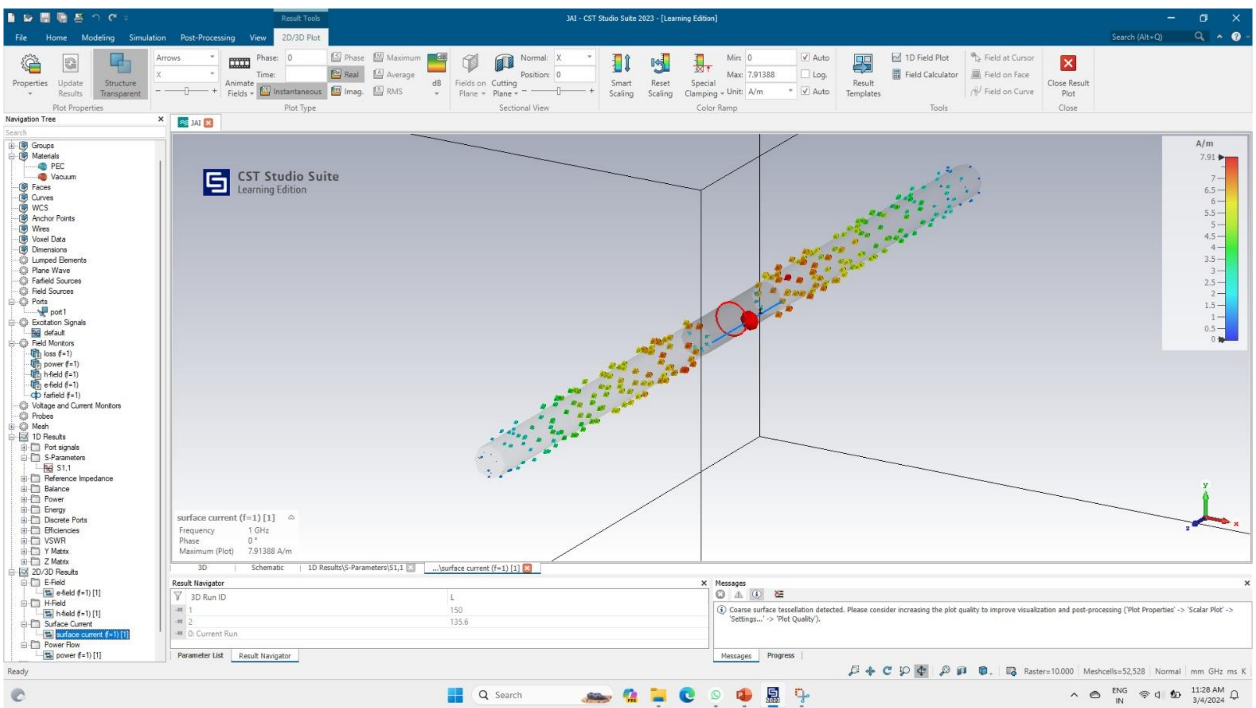


fig 3.6.2.7

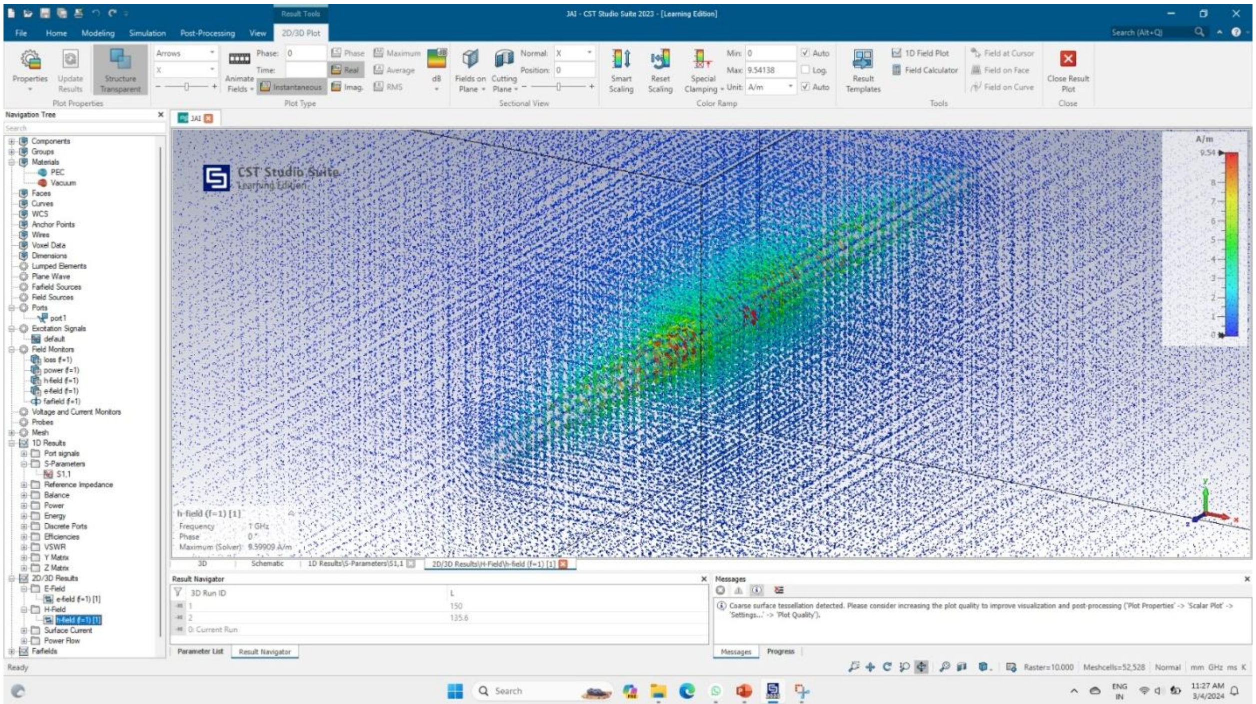


fig 3.6.2.7

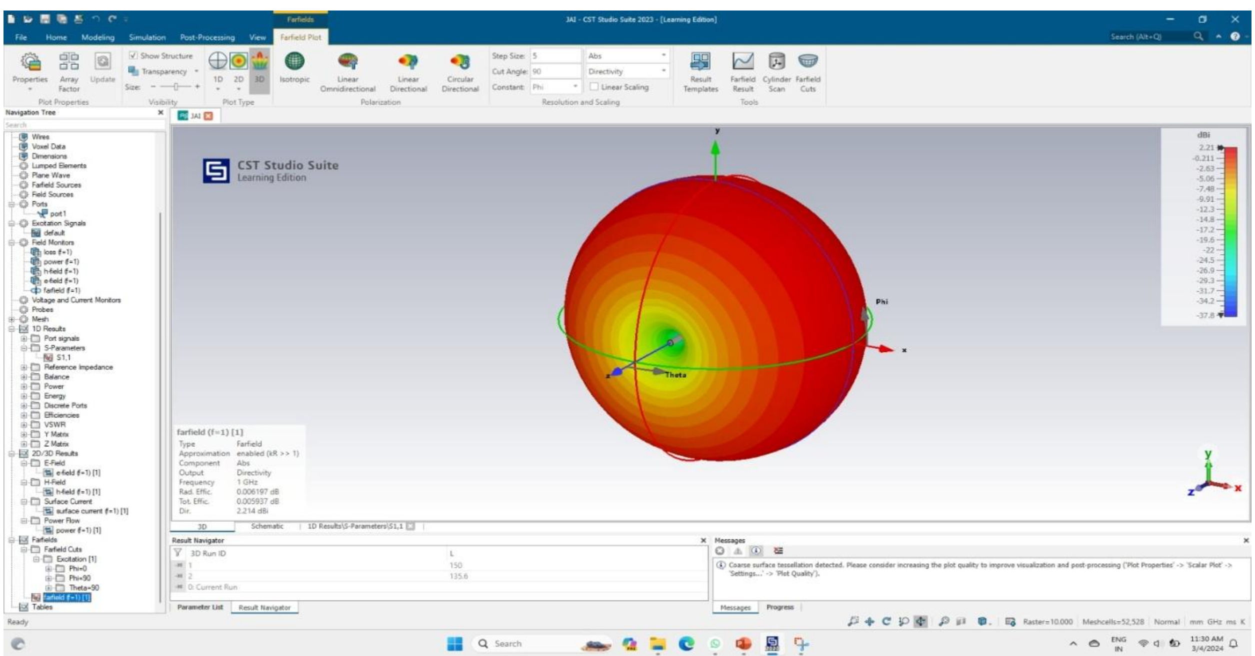


fig 3.6.2.8

This step shows adding feedline in antenna.

Step Five

When the initial four steps have been completed by an HFSS user, the model is now ready to be analysed. The time required for an analysis is highly dependent upon the model geometry, the solution frequency, and available computer resources. A solution can take from a few seconds, to the time needed to get a coffee, to an overnight run. It is often beneficial to use the remote solve capability of HFSS to send a particular simulation run to another computer that is local to the user's site. This will free up the user's PC so it can be used to perform other work.

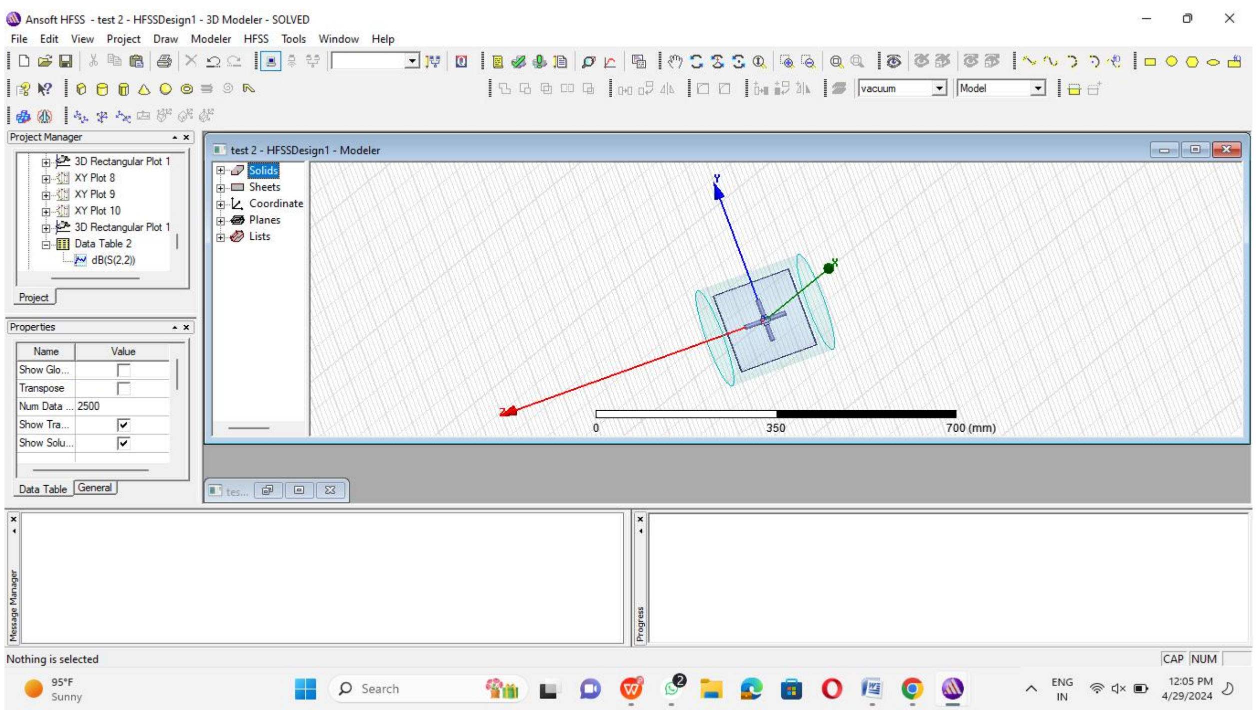


fig 3.6.2.9

Step Six

Once the solution has finished, a user can post-process the results. Post processing of results can be as simple as examining the S-parameters of the device modelled or plotting the fields in and around the structure. Users can also examine the far fields created by an antenna. In essence, any field quantity or X, Y, Z parameter can be plotted in the post-processor. Additionally, if a parameterized model has been analysed, families of curves can be created.

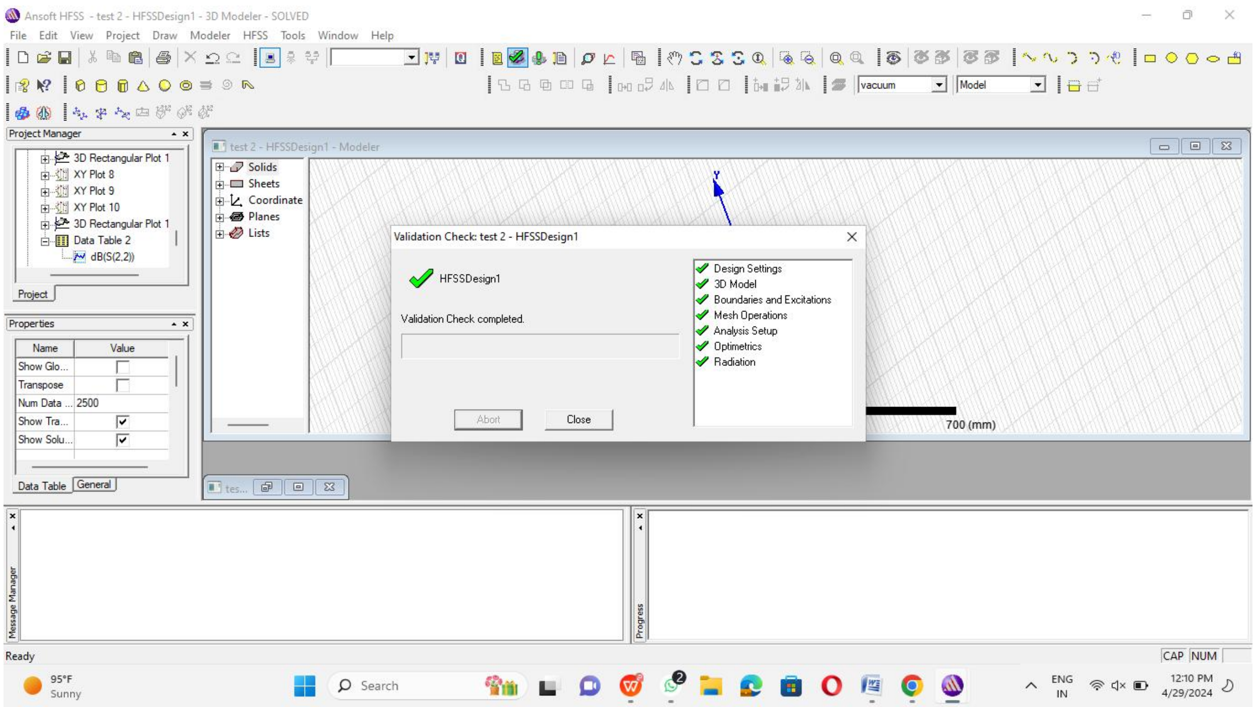


fig 3.6.2.10

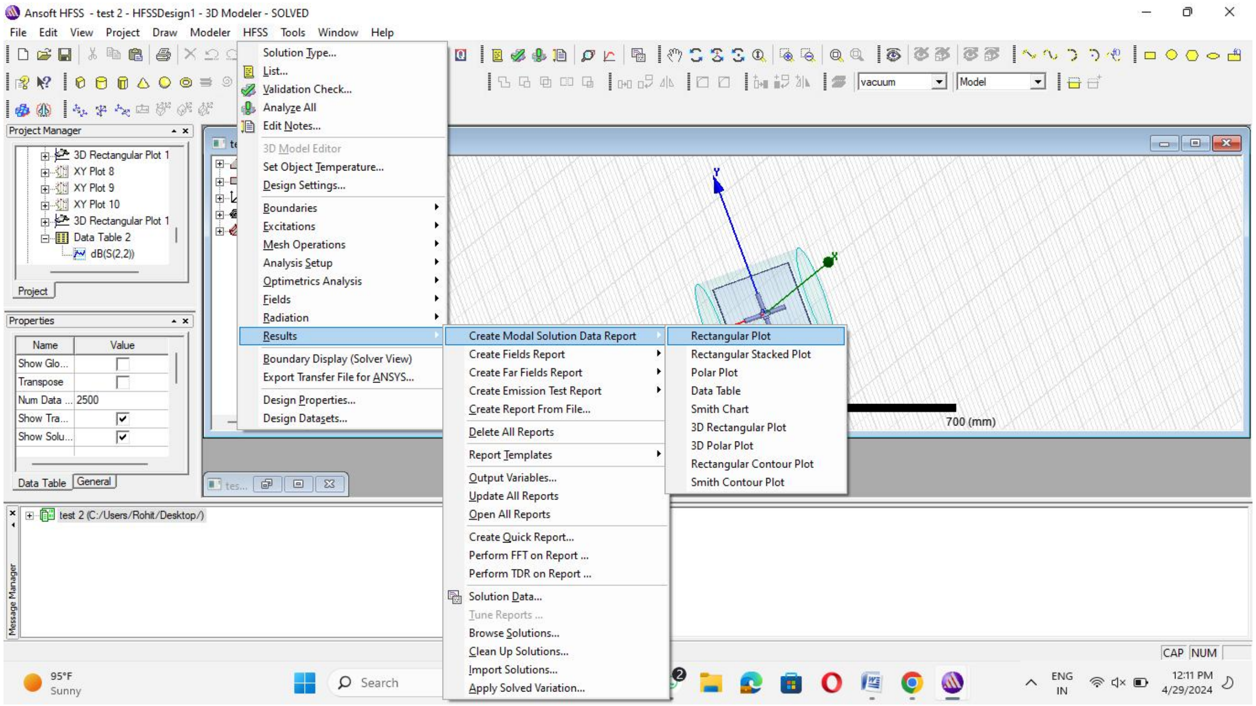


fig 3.6.2.11

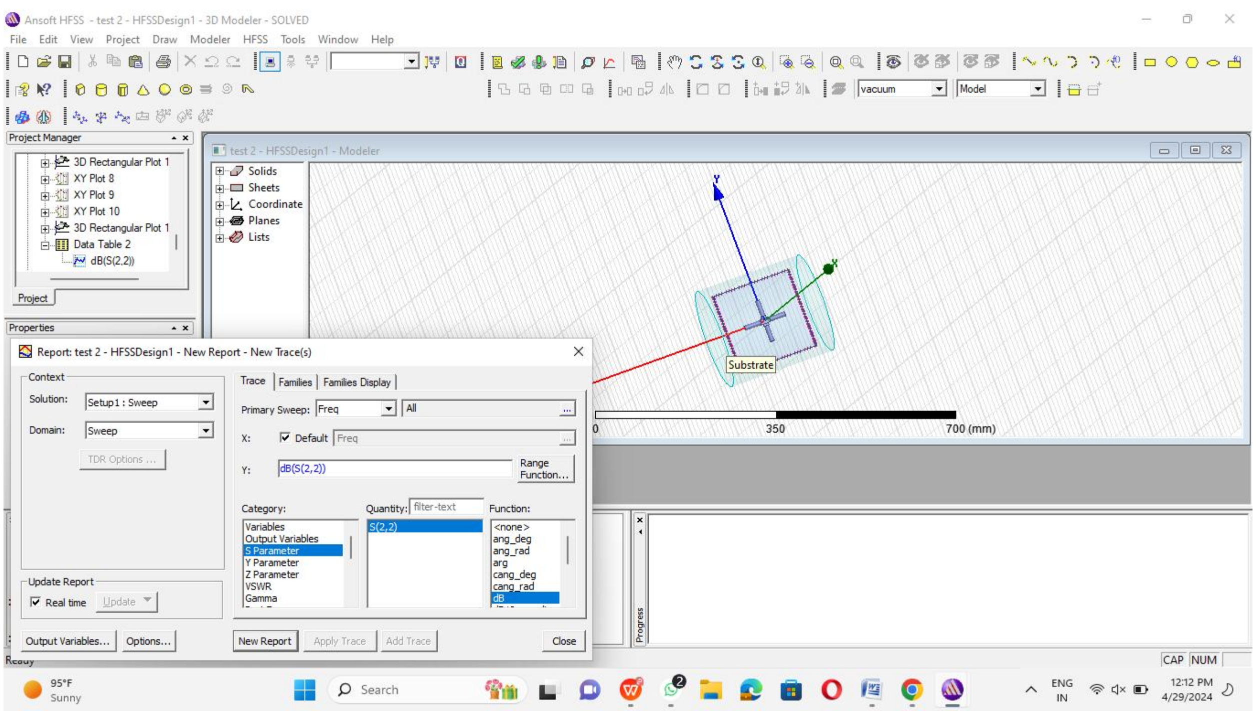


fig 3.6.2.12

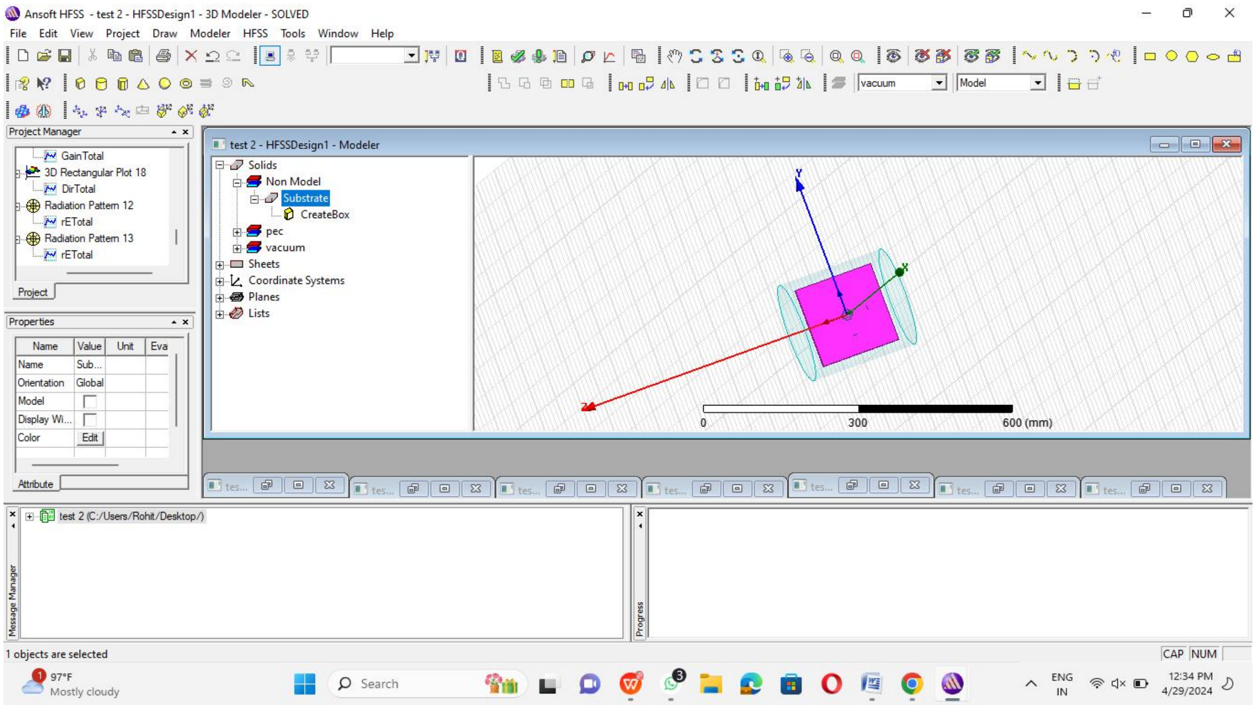


fig 3.6.2.13

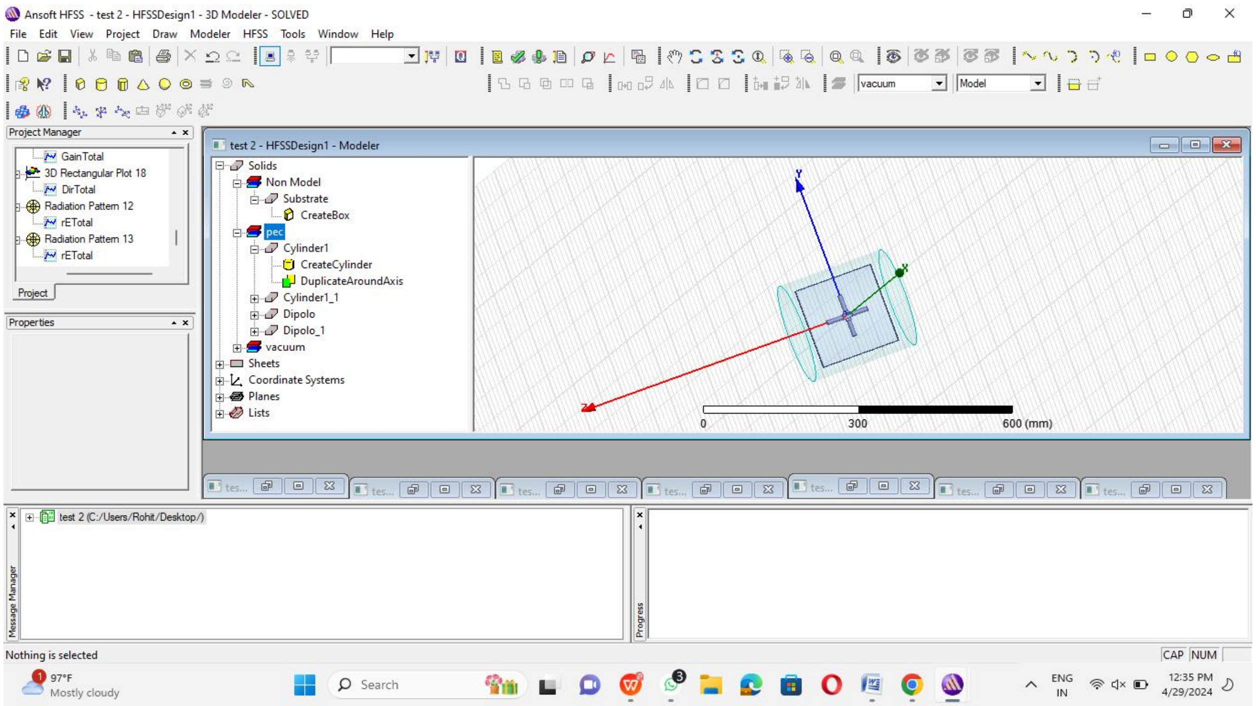


fig 3.6.2.14

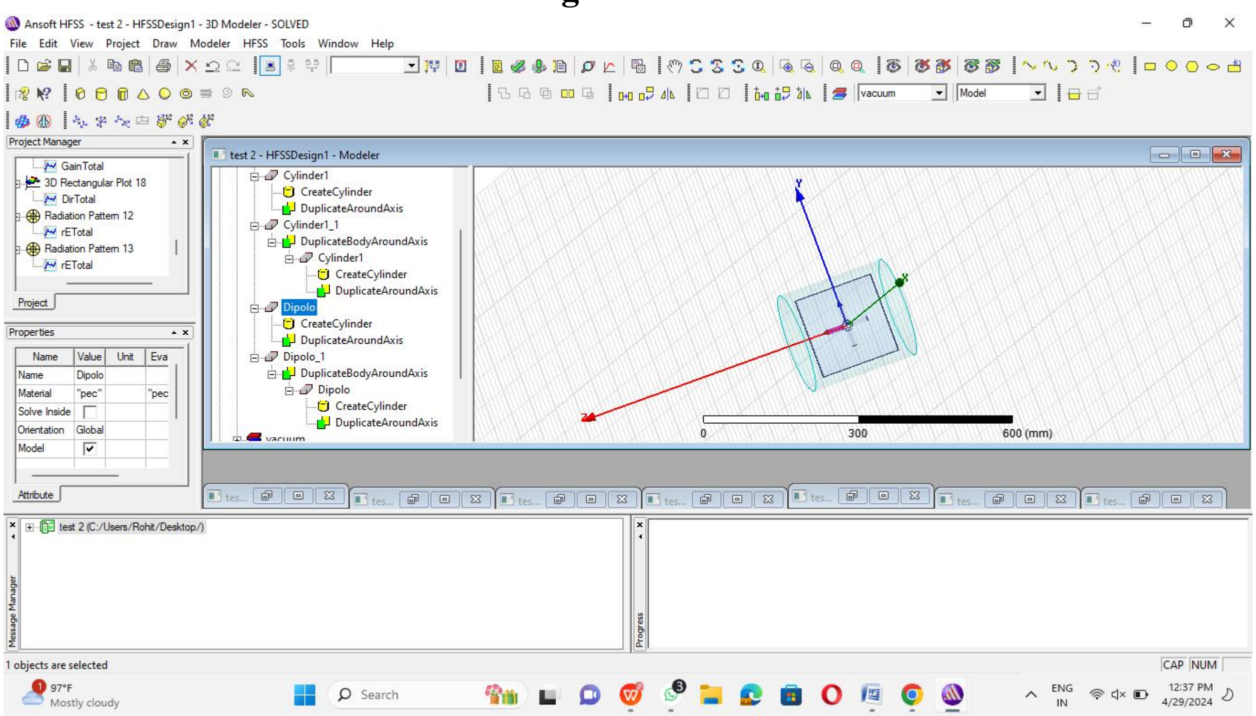


fig 3.6.2.15

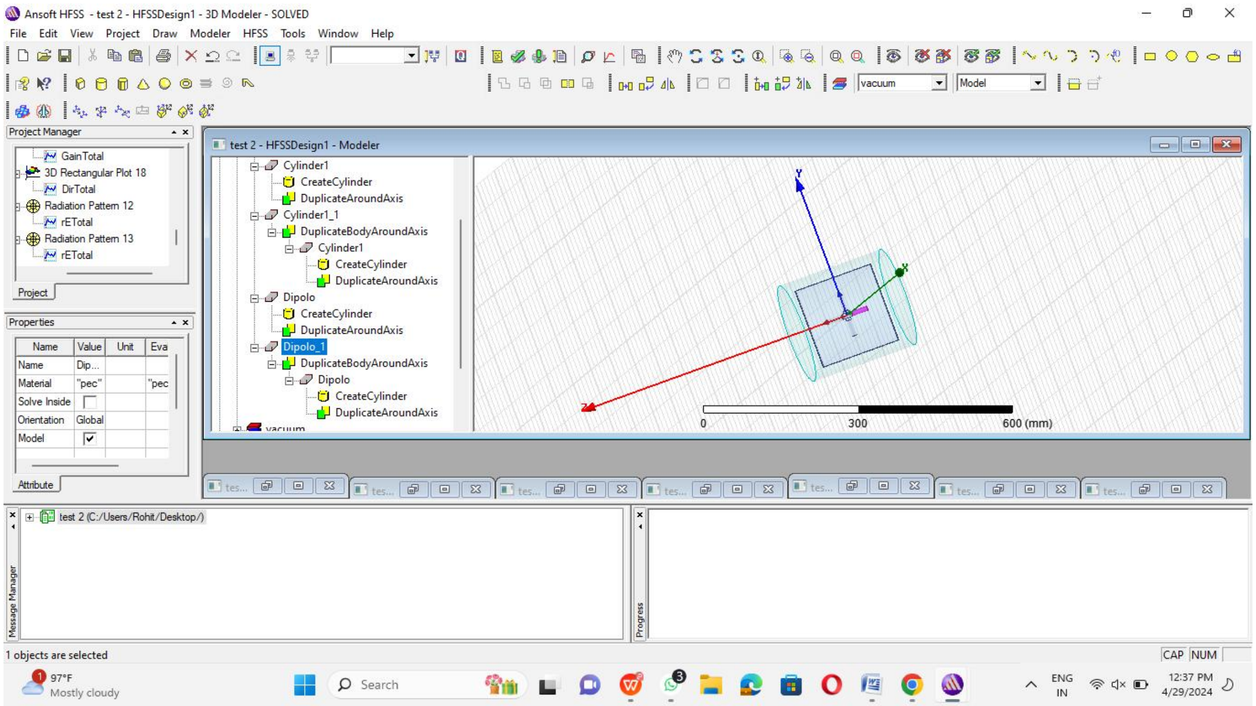


fig 3.6.2.16

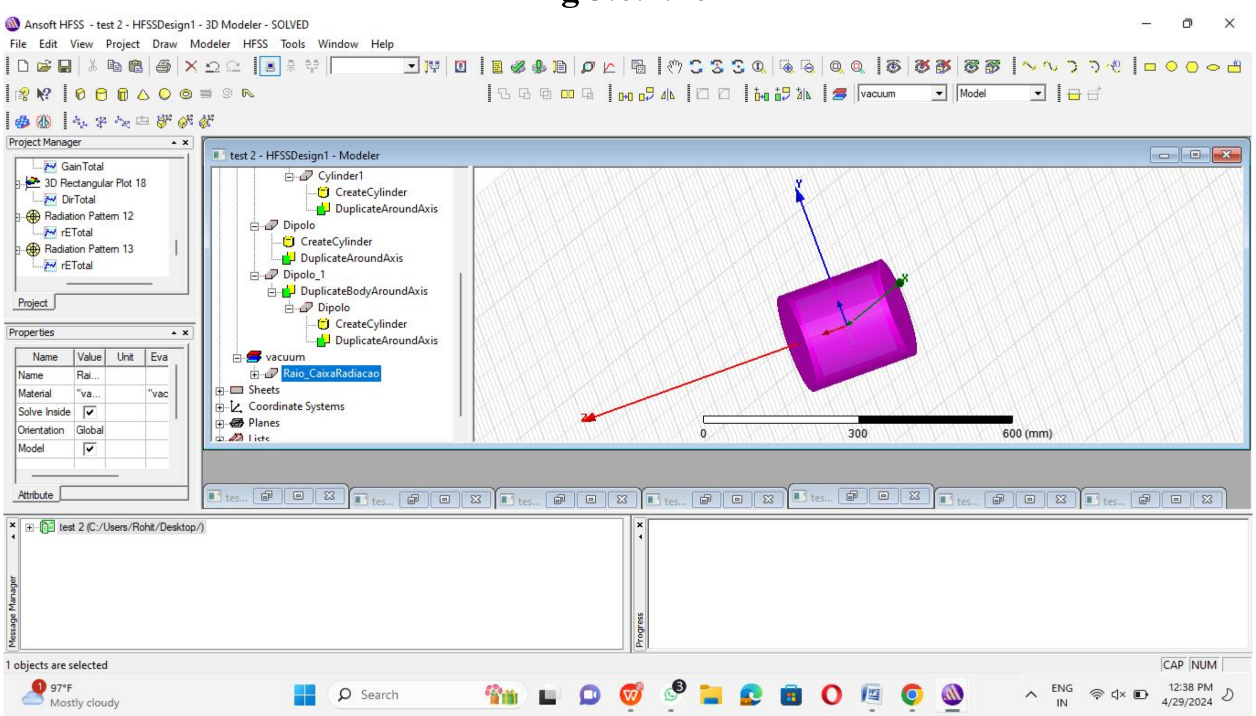


fig 3.6.2.17

3.6.3 3D Modeling

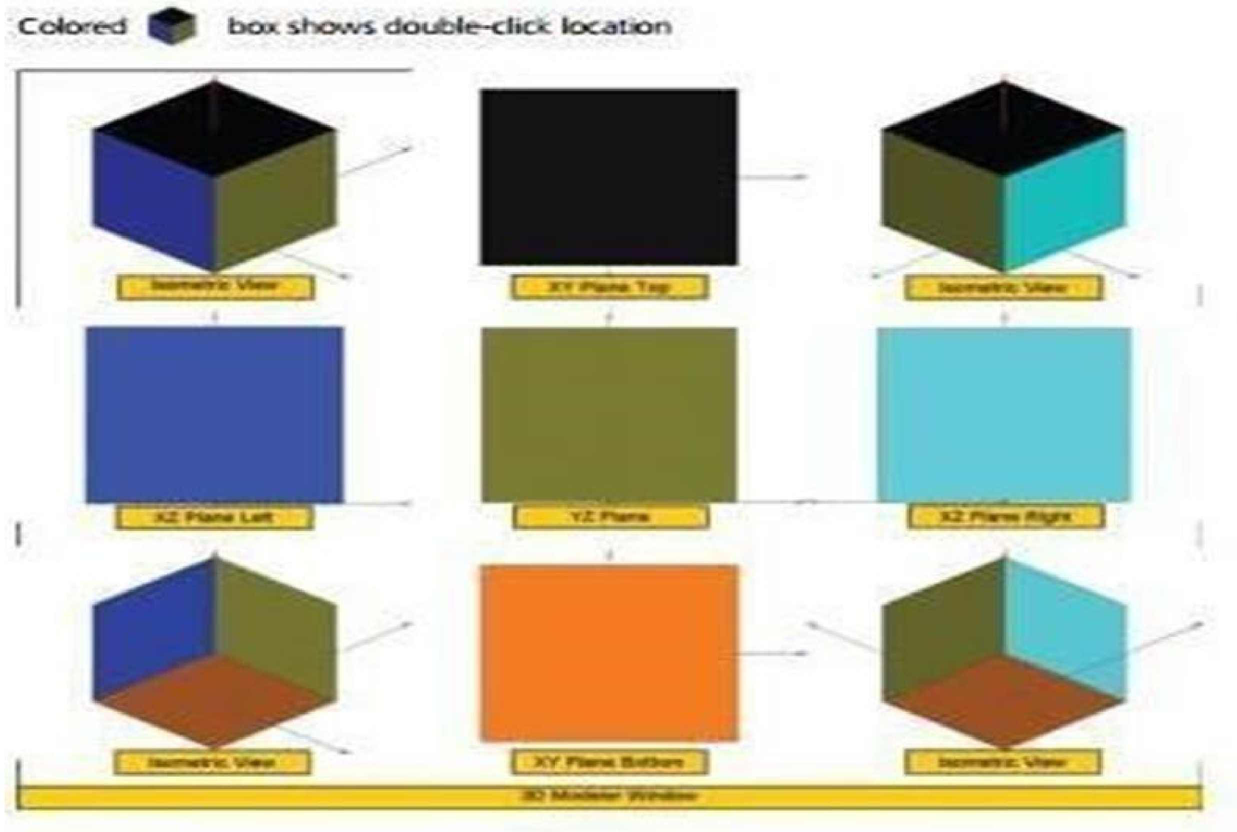


Fig 3.6.3 : 3D modeling

Hot keys are specific keys or a combination of keys that have a specific purpose. The most common hot keys are for pan, rotate, and zoom. Additionally, hotkeys can be used to produce planar XY, YZ, XZ, and the standard isometric views of objects in the modeling window.

Press key.0,2,4,6,8-Rotate model in various direction.

Alt + SHIFT + Left Mouse Button: Zoom in Boundaries
There are twelve boundaries available within CST. Boundaries are applied to specifically create 2D sheet objects, or surfaces of 3D objects.

The twelve boundaries are
Perfect Electric Conductor (PEC): Default CST boundary fully encloses the solution Space and creates a closed model

1.Radiation: Used to create an open model

2. Perfectly Matched layer (PML): Used to create an open model and preferred for antenna simulations

3. Finite Conductivity: Allows creation of single layer conductors

4. Layered Impedance: Allows creation of multilayer conductors and thin dielectrics

5. Impedance: Allows creation of ohm per square material layers

6. Lumped RLC: Allows creation of ideal lumped components

7. Symmetry: Used to enforce a symmetry boundary

8. Master: Used in conjunction with Slave Boundary to model infinitely large repeating array structures

9. Slave: Used in conjunction with Master Boundary to model large infinitely repeating array structures

10. Screening Impedance: Allows creation of large screens or grids

11. Perfect H: Allows creation of a symmetry plane Excitations

A wave Port is the most commonly used type of excitation used in HFSS. This port type is very useful for exciting micro strip, stripline, coaxial, or waveguide transmission lines. It should be applied only to an outer face of the solution space.co axial based feeding and dielectric resonator based feeding has been analyzed below here. Excitations Lumped Ports

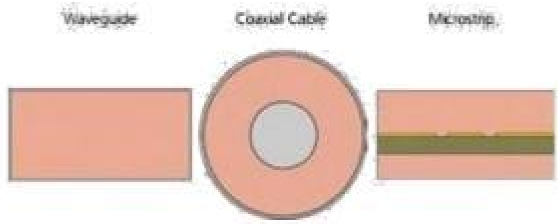


Fig 3.7: Dielectric resonator based feeding

Lumped Ports are the other commonly used excitation type in HFSS. This port type is analogous to a current sheet source and can also be used to excite commonly used transmission lines. Lumped ports are also useful to excite voltage gaps or other instances where wave ports are not applicable. They should only be applied internally to the solution space. Shown below are examples of commonly used wave ports with proper size dimensions.

3.6.4 Port refinement and analysis

The Maximum number of passes is the maximum number of adaptive iterations HFSS performs in order to reach convergence. The Maximum refinement per pass is the percentage of tetrahedral elements that are subdivided with each adaptive pass.

Assigning boundaries in the GUI :
Boundaries are assigned to specifically create 2D object in an HFSS model
or to specific faces of 3D objects.
To assign a boundary to a 2D object or 3D face, simply change to the select faces mode and select the appropriate 2D object or 3D face. If a common boundary is to be applied to multiple faces, the multiple faces can be selected by holding the CTRL key. Once all the desired faces have been selected, simply perform a right mouse button click and select Assign Boundary. Finally, select the desired boundary. Alternatively, once all the faces have been selected, a user can click on HFSS in the top-level menu bar, select boundaries, choose assign, and select the desired boundary.

3.6.5 Plotting field results

HFSS can produce a plot of any standard electromagnetic quantity, such as the electric field, magnetic field, Pointing vector, or current density. Generally, fields are displayed on specifically created 2D objects, faces of 3D objects, or on coordinate system planes. Plots can be scalar quantity plots or vector quantity plots. Specific quantities based on mathematical operations on the basic field quantities can also be plotted by use of the field‘s calculator.

Field plots, or, more specifically, field overlays, are representations of the basic or derived field quantities on specific surfaces of objects or within an object for the current design variation. A field overlay‘s appearance can be changed by58 modifying the settings in the Plot attributes dialog. This dialog modifies a plot folder and all field overlays contained within that folder will use the same attributes. Field overlays can also be created by the use of the field calculator. The field calculator allows a user to create mathematical operations on the basic field quantities. These results can be plotted or exported depending on the needs of the user.

3.7 DESIGN OF ANTENNA

3.7.1 Design Method

The simplified formulation discussed in the previous sections above involves the procedure for designing a rectangular ME-dipole antenna. This procedure involves the specification of the substrate that will be used, the resonant frequency and the thickness of the substrate. Once these parameters are derived the width and the length of the patch is determined using the relationship.

The design of the rectangular patch antenna, these essential are required: Frequency of operation (f): This is also known as the Resonant Frequency; it is essential to select an appropriate resonant frequency of the antenna. Communication systems make use of frequency ranging from 1800 – 5600 MHz, therefore the antenna must be designed to operate in this frequency range .

The frequency selected for my design is between 1.8GHz – 3.0GHz. Therefore, the resonant frequency is employed.

Dielectric constant of the substrate : This is referred to as the Effective Permittivity of the substrate. The dielectric material used for my design is Raio_caoixaRadiacao consisting of a dielectric constant of 1-1.7.

3.7.2 Antenna Design Template

The design of a rectangular patch antenna was developed using essential equations required to perform this process. The rectangular patch design parameters were obtained using equations (3.1), (3.2), (3.3), (3.4) and (3.5).

The width of the patch is obtained by:

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r+1)}{2}}}$$

Where

C= Speed of light f0=resonant frequency.

εr = Effective permittivity.

Also the length of the patch was determined using: The effective constant of the ME-dipole antenna is derived using:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\,\frac{h}{W}\right]^{\frac{1}{2}}$$

Where

εreff= Effective dielectric constant

εr = Dielectric constant of substrate

h = Height of the dielectric substrate.

W = Width of the patch

The extension length is also achieved using the equation below:

$$\Delta L = 0.412h\,\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)}$$

Where
εreff= Effective dielectric constant
εr = Dielectric constant of substrate
h = Height of the dielectric substrate.
W = Width of the patch

While the actual length of the patch is determined by:

L=Leff−2Δ

Where $L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}}$

The ground dimension of the antenna are essential to have a finite ground plane. The size of the ground plane is greater than the patch dimensions by approximately six times the height of the substrate. This is given as:

$$Lg=6h+L$$
$$Wg=6h+W$$

3.7.3 Simulation

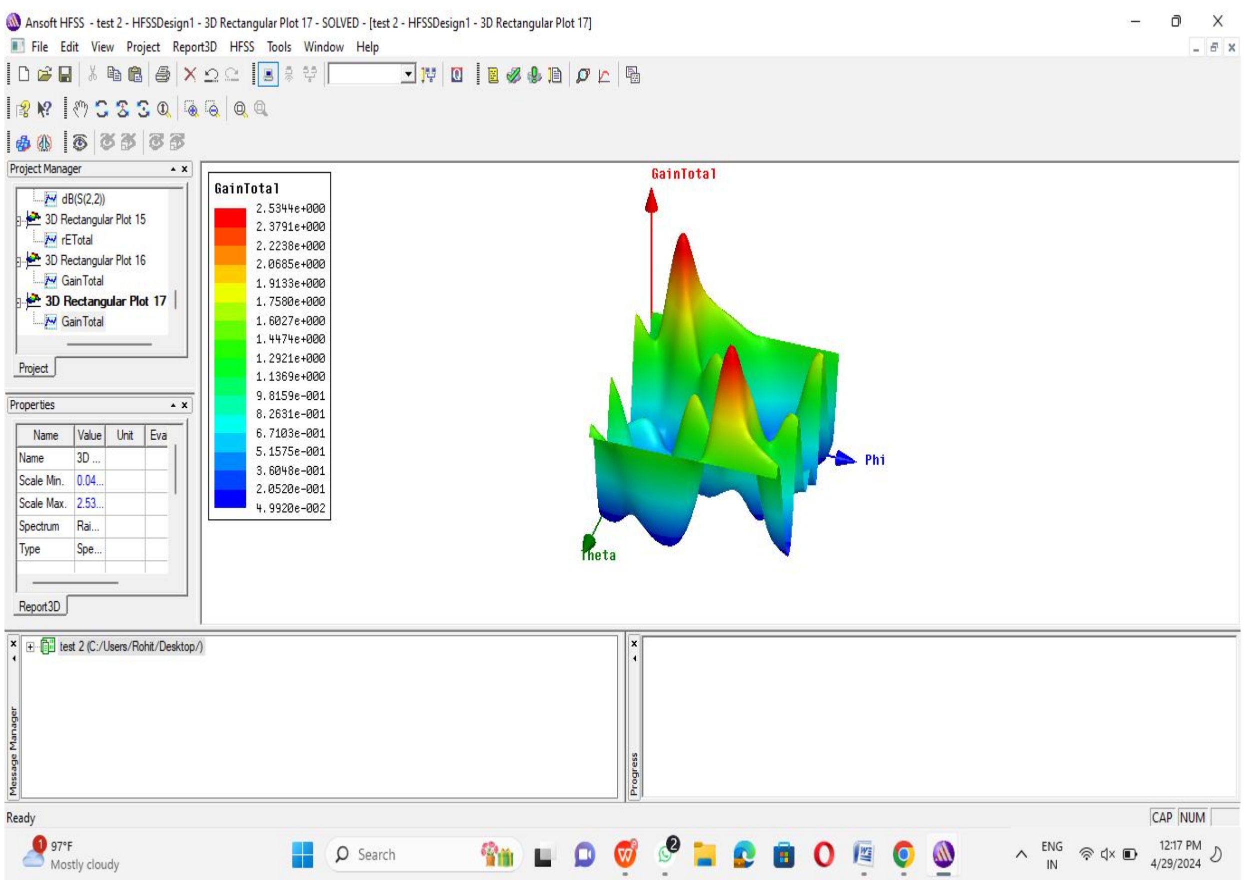
The specifications stated above are simulated in HFSS using appropriate equations to derive the parameters of the patch and the Ground Dimensions. This is shown on the Graphical User Interface (GUI) on HFSS as shown in figure 3.1, which fits the given specifications 3.4.1

CHAPTER 4

RESULTS AND DISCUSSION

The result shown in figure 4.1 denotes the polar plot (gain), radiation pattern of the designed antenna at the resonant frequency of 16GHz. The E-plane of the radiation pattern is the plane containing the electric field vector ( ) and the direction maximum radiation while the H-plane pattern consist of the magnetic field vector ( ) with the direction of maximum radiation and the cross polarization component. The wide bandwidth was obtained for the antenna with a gain of 10dB.

4.1 Gain plot :



4.2 Radiation pattern :

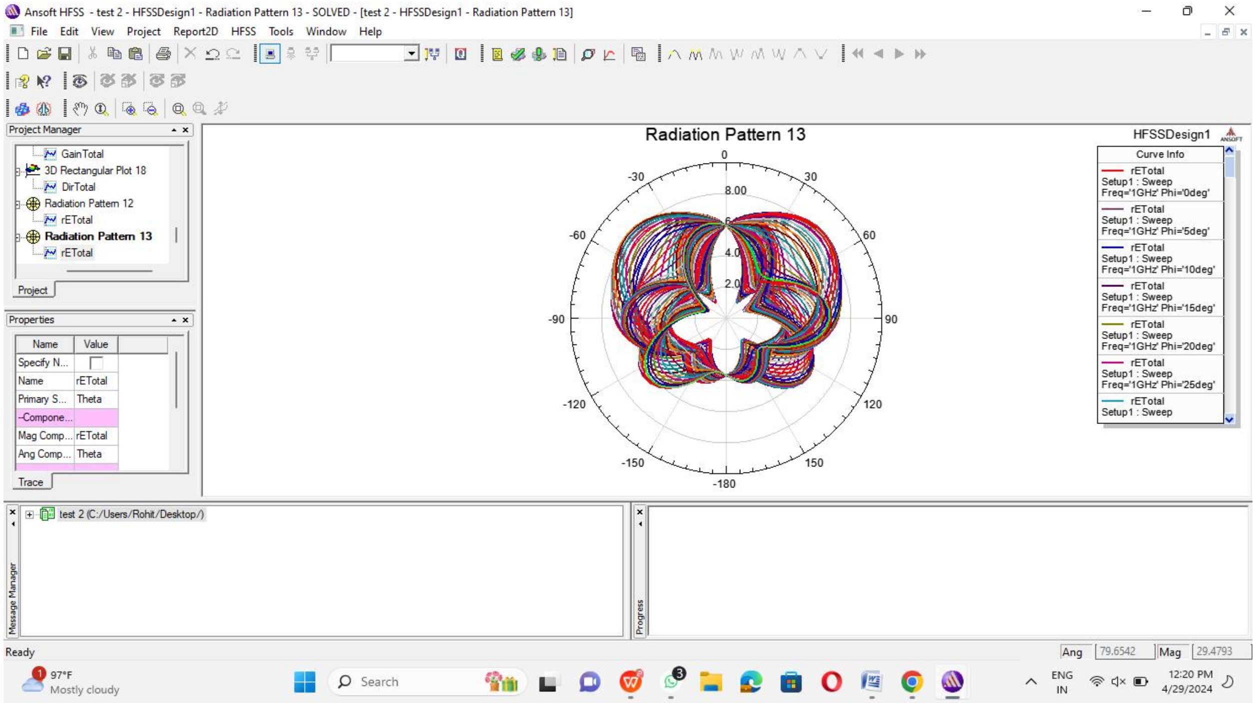


Fig 4.2 Radiation Pattern

It is defined for large distances from the antenna, where the spatial (angular) distribution of the radiated power does not depend on the distance from the radiation source. It is usually different for different frequencies and different polarizations of radio wave radiated/ received.

4.3 XY PLOT (S-Parameter)

S-parameters for a magneto-electric dipole antenna quantify its interaction with the surrounding environment, aiding in understanding its impedance matching, reflection properties, and radiation efficiency across different frequencies. These parameters facilitate optimization of antenna performance and integration into microwave systems.

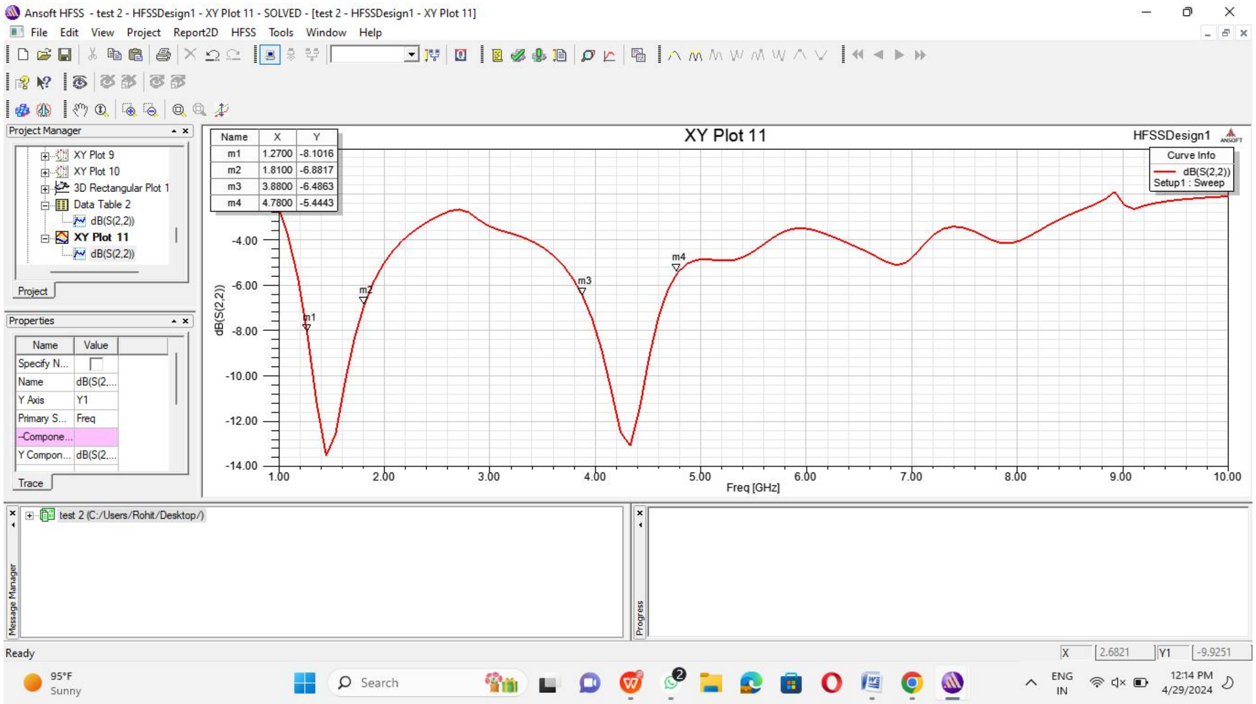


Fig 4.3 XY Plot

4.4 Directivity

The figure 4.4 shows the directivity of the designed antenna. It is a measure of how directional an antenna‘s radiation pattern is. Efficiency of an antenna is the , directivity describes how well an antenna or system concentrates its energy or sensitivity in a particular direction, as opposed to radiating or receiving energy equally in all directions (omni directional pattern). An antenna with high directivity has a narrower radiation pattern and is more focused, whereas an antenna with low directivity has a wider radiation pattern and is less focused. ratio of gain and directivity.

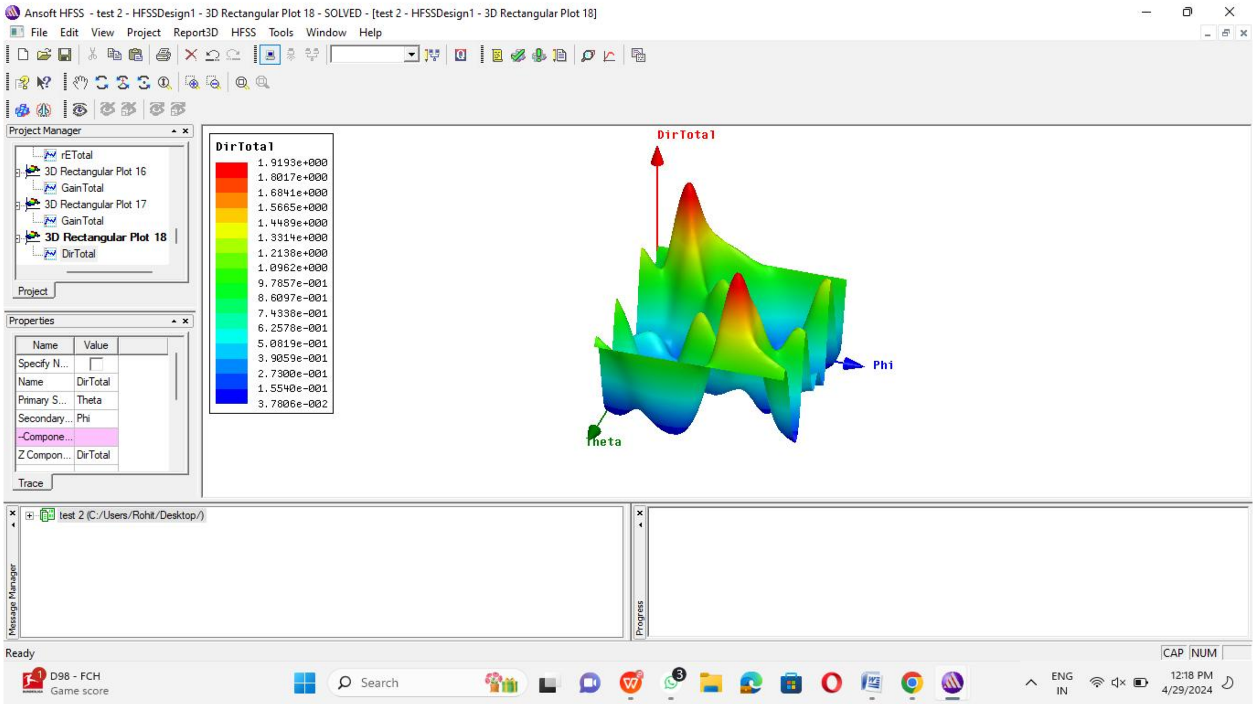


Figure 4.4 Directivity

4.5 Tabulation

SERIAL NO	**ANTENNA TYPE**	MAGNETO ELECTRIC DIPOLE ANTENNA
1	**DIELECTRIC CONSTANT**	1-1.7
2	**BAND WIDTH**	2.55-3GHz
3	**GAIN**	9.8 dBi
4	**DIRECTIVITY**	9.7dBi
5	**RESONANCE FREQUENCY**	16 GHz

4.6 APPLICATIONS AND ADVANTAGES

4.6.1 APPLICATIONS

1. 5G applications
2. Radio frequency identifications
3. Near-Field Communication (NFC)
4. Internet of Things (IoT)
5. Satellite communication

4.6.2 ADVANTAGES

1. Broadband Performance
2. Compact Size
3. Dual Polarization Capability
4. Low Profile and Low Cost
5. Low cross polarization

CHAPTER 5
CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

The design of a high-gain magneto-electric dipole antenna by loading a magneto-electric dipole director has shown significant improvements in antenna performance, particularly in terms of gain and VSWR. The addition of a director above the horizontal copper patches, which serve as the driven system, has been instrumental in enhancing the radiation performance of the antenna unit. This is evidenced by the simulation results that demonstrate an increase in the electric field strength on the radiation patches, leading to improved antenna gain and VSWR across the operating frequency band.

The structural evolution of the magneto-electric dipole antenna, including the integration of parasitic patches and the use of a director, has resulted in a design that offers good isolation between ports and stability in the operating frequency band. The antenna's geometry, which includes the use of copper for the ME dipole elements, parasitic patches, and director, along with 3D printed plastic fasteners for structural reinforcement, contributes to its strong mechanical structure and lightweight design. These advancements in the design and structure of magneto-electric dipole antennas have paved the way for more efficient and effective wireless communication systems, particularly in the context of 5G and beyond.

5.2 FUTURE SCOPE

The future of ME dipole antenna design is likely to focus on miniaturization, performance enhancement through met surfaces, beam width reconfiguration, anti-interference capabilities, and the development of wideband and circularly polarized antennas. These advancements will be crucial for the successful deployment of 5G networks, which require efficient spectrum utilization, high data rates, and low latency.

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