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Design and Simulation of Microstrip Patch Antennas for Wearable Technology Applications

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Abstract-- In today's technology world, wireless communication via portable devices is thriving. This work covers the design, modeling, and analysis of microstrip antennas. Rogger RT/Duroid 5880, a substrate material with a dielectric permitivity of 4.3, was used to construct this design. Also, the antenna's tangent loss is 0.035 and its thickness is 0.1 mm. The virtual specifications of the antenna are as follows: frequency response= 128.9 MHz, directivity gain=1.22, bandwidth= 6.73 dBi, and return loss VSWR= -19.89 dB. With this antenna, we want to achieve a standardVSWR while simultaneously decreasing the S-parameter.

1.INTRODUCTION

Microstrip antennas have been an invention in wireless communication systems, meeting a need in the modern era of wireless communication that is in step with technological advancements. All of these devices make use of microstrip antennas because to its several benefits, such as being very efficient, lightweight, and having a simple structure. Restrictions on its application in wireless systems are caused by its restricted operational bandwidth, however. In recent years, wireless devices and broadband applications have become indispensable in our day-to-day communication lives. Consequently, there is less of a need for low profile wideband. The majority of mobile and satellite equipment requirements are met by microstrip antennas, and many business needs are met as a result of their use. In a world where the number of electrical circuits needed for wireless applications is steadily decreasing, microstrip is a great fit. Additionally, the majority of antennas are seeing a significant reduction in size. Meeting these requirements is the goal of the microstrip antenna fix design. One cause for improvement, among others, is the microstrip antenna's correct impedance bandwidth, which has been investigated using several methodologies. Several studies

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have shown the widespread presence of the carving impact of slots and notches in its expansion. An extremely simple version of the microstrip antenna may be made by adhering a radiating conducting material to the top of a dielectric substrate. Microstrip patch antennas are becoming more popular because of their small size, modest gain, limited bandwidth, and low weight.

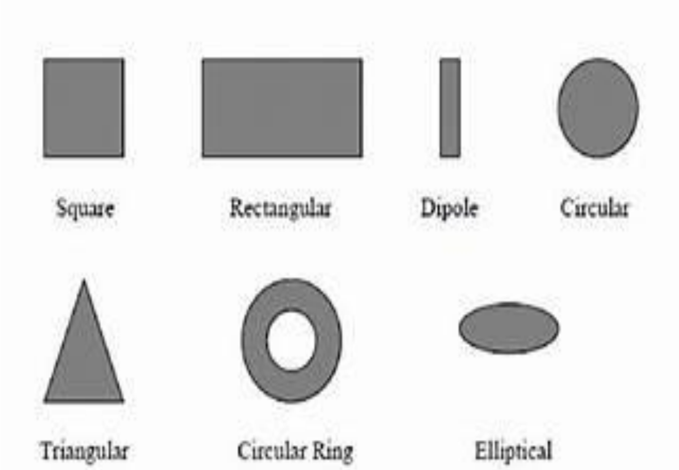
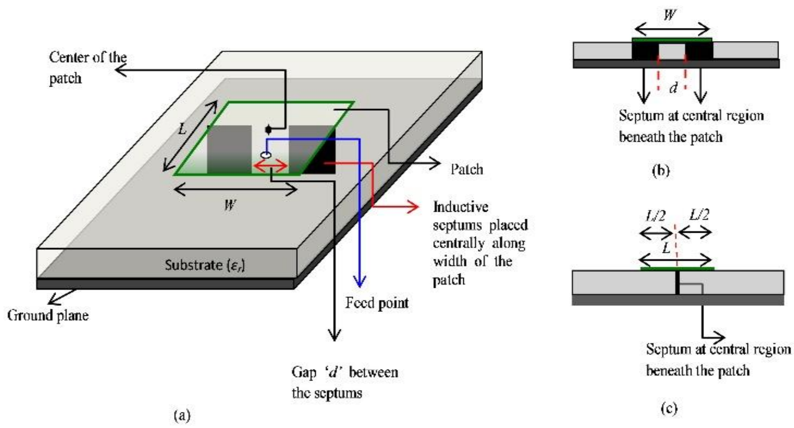


Fig 1: Design and Simulation

A microstrip patch antenna relies heavily on a metal patch. A microstrip patch antenna is an electromagnetic device that can transmit and receive microwave frequencies.



Antenna dimensions (length, breadth, substrate thickness), substrate material dielectric constant, feed line location, and microstrip patch antenna performance are all critical. Forms such as rectangles, squares, circles, triangles, dipoles, and more are all possible using microstrip patch antennas. Figure 1 displays several antenna shapes.

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The importance of microstrip patch antennas in modern wireless communication systems is growing. A few examples of antennas include the folding dipole, patch, slot, and parabolic reflector types. There is a wide variety of antennas, each designed for a particular purpose and boasting its unique set of characteristics.

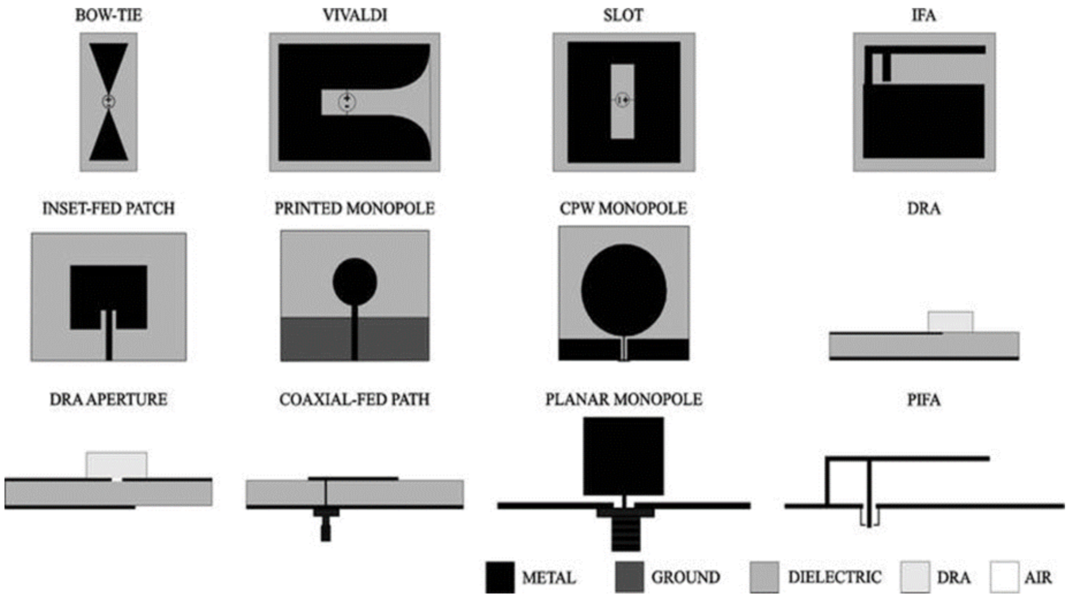

Fig 2 : Fractal and Polar Microstrip Antennas

2.Structure and Characteristics

The ground plane, dielectric substrate, patch, and feeding line are the four primary components of a microstrip antenna. An electrically conductive ground plane is etched onto the underside of a dielectric substrate. The design of this antenna makes advantage of a wide variety of dielectric substrates, each with its own unique spectrum of dielectric constant values. The purpose of this work is to present 3.55 GHz band channel characterizations. To be compatible with the latest generation of tiny speaking devices, the antenna has to be compact. Having a high performance and advantage will allow the original records to switch in any wireless communication area.

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Characteristics	Microstrip Patch Antenna	Printed Dipole Antenna
Profile	Thin	Thin
Fabrication	Very Easy	Easy
Polarization	Both Linear & Circular	Linear
Shape Flexibility	Any Shape	Rectangular & Triangular
Bandwidth	2 - 50%	~30%

Fig: 3: Characteristics of Microstrip patch Antenna

This work has been divided into five sections to better arrange the supplied material. In addition, there is an introduction, a literature review, sections dealing with materials and techniques, sections dealing with antenna design and simulation, sections dealing with analysis of data, and sections dealing with conclusions.

2.1 Wearable Devices :

The proliferation of wireless networks and other electrical devices has led to the widespread use of wireless body area networks. To improve WBAN in its many forms, one may employ a wearable patch antenna. The purpose of this research is to propose and construct a low-profile wearable microstrip patch antenna for continuous monitoring of human vital signs using wireless body area network (WBAN) technology. The antenna is designed to operate inside the 2.45 GHz frequency range, which is part of the ISM (industrial, scientific, and medical) spectrum. The substrate material is polyester textile fabric with a thickness of 2.85 mm and a relative permittivity of 1.44. When compared to other wearable antennas on the market, the suggested one outperforms them in terms of return loss, VSWR, gain, and specific absorption rate (SAR). Antenna gain of 7.81 dB and return loss of about -10.52 dB were obtained at 2.45 GHz. As far as impedance matching goes, the 2.45 GHz VSWR value of 1.84 is satisfactory. Gain in two and three dimensions, radiation pattern, and SAR value are some of the other antenna field metrics that have been computed. To plan and test the suggested antenna, we use the High-Frequency Structure Simulator (HFSS).

2.2 5G

There has been a development period for 5G technology. The primary cause of this is the exponential growth of mobile traffic. As a result, there will be a greater need for bandwidth and fast data rates. Using MIMO (Multiple Input, Multiple Output), we can fix this issue. By using the multipath feature without altering the input power, MIMO offers increased data speeds, better spectral efficiency, and channel capacity. It is expected that MIMO has both high element isolation and broadband. In order to provide wider bandwidth and greater data rates, 5G aims to use the 3-300 GHz spectrum. Another factor affecting the range is the fact that numerous wireless technologies are currently making use of the lower spectrum, leaving the upper spectrum untapped and potentially useful for 5G applications. The problem of higher frequency free space propagation emerges when the higher spectrum is used. While these frequencies do not cover too much ground, the frequency reuse feature makes up for it.

Fig 4: 5G microstrip patch antenna

2.3 Objectives :

Fabricating the microantenna on PCB for wearable devices is an extremely challenging sector, driven by downsizing and advancements in FC Fabrication technology. We propose a method to create and model a miniature patch antenna with an improved dielectric constant and strength by use of a newly created nanocomposite material. Antenna size and radiation at the operational frequency are linked to the dielectric factor. A glassy epoxy nanocomposite material has been used.

3.Literature Survey :

There have been a number of investigations on microstrip patch antennas over the years.

The increased power sent to the receiver by high-gain antennas is one issue. A stronger received signal is achieved by doing this. Since they work in the opposite direction, high-gain antennas may boost the received signal intensity by a factor of 100 when transmitting. Directional antennas are less effective in transmitting signals from directions other than the primary beam because of their directivity. This quality makes interference less noticeable. Wireless communication may achieve a high gain with this technology, allowing for much stronger data transmissions compared to earlier studies.

To address the lower frequency spectrum of the 5G network, which is around 3 GHz, Swarna et al. [4] developed a novel slot-loaded microstrip patch antenna with a helipad-looking ground modification. Antenna performance is optimized for the resonance frequency inside the S-band. Based on the modeling results, the bandwidth is around 1.78 GHz, which is over eighteen times higher than a typical MPA with a complete ground plane. The MPA's larger capacity is the reason for this rise. A non-spherical, bidirectional radiation pattern is seen in both the existing and projected MPAs. Beamforming, WLANs, and intersatellite communication are just a few of the many potential applications of the proposed MPA's bidirectional radiation pattern.

In this study, Bae and Yoon [15] suggested a shared-aperture antenna operating in the S- and Ka-bands for 5G networks. An S-band thick patch was used to create this paper, which is surrounded by sixteen Ka-band slotted cavity antennas. Because of this, the bandwidth of the antenna array has been enhanced. In the Ka-band, each component of the slotted cavity antenna receives its signal from its own coaxial connection. An S-band driving frequency microstrip-fed slot has been included into the TPCSCA design. The results of the testing validated the concept, and it is anticipated that this will enhance the aperture's performance in 5G dual-band applications.

4.Design and Material Selection

The method of doing the MPA is determined by the buildings' physical size and the characteristics of the materials used in their construction. Because of its simplicity in both construction and presentation, a fixed rectangular form is used in this analysis. In addition, its greater length allows it to

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transmit impedances more quickly than other forms of receiving wire.

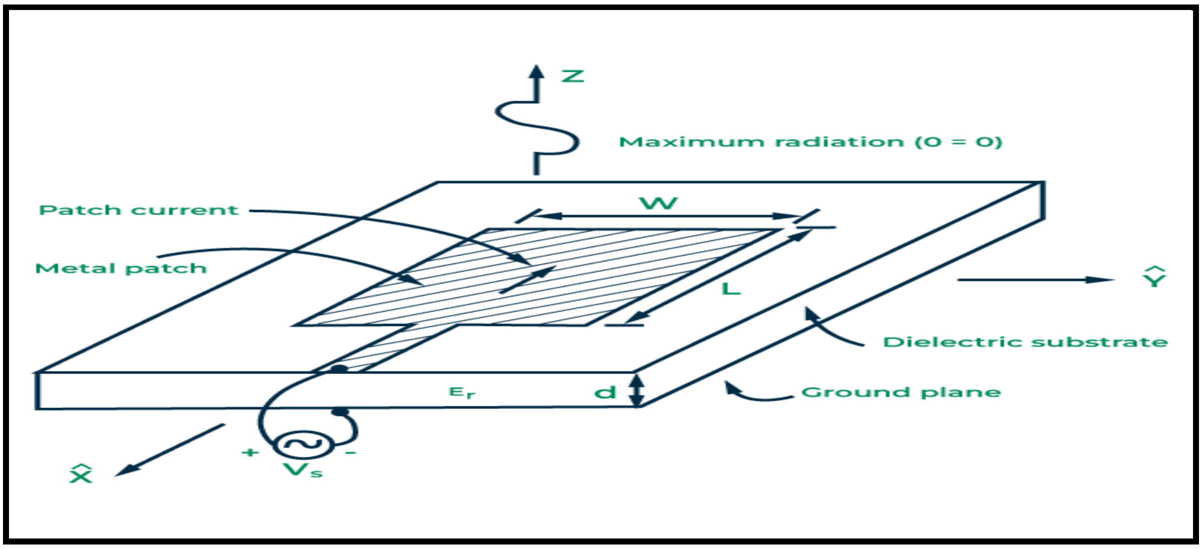


Fig 5 : Design architecture of Microstrip Patch Antenna

An electromagnetic wave's path is altered by the capacitance effect of a conductor embedded in or around an insulating substance. This effect provides an approximate measure of the magnitude to which the capacitance of a conductor alters the propagation of an electromagnetic wave. The dielectric constant determines the receiving wire's viability in its whole. As the reverberation frequency is affected by breadth, characteristic impedance, and length, the transmission rate is reduced and the time it takes for reverberation to occur again is increased. Managing the surrounding region, the principal radiation source in microstrip fix receiving wires, and the dielectric consistency are all components of the dielectric field.

The reduced value of driving will lead to improved transmission capacity and productivity, which in turn will cause the boundaries to be more widespread and the radiation to be much better. Additionally, the dielectric constant controls the boundary field, the primary radiation source in microstrip fixed radio cables.

4.1 Design :

The 2 × 2 and 3 × 3 antenna arrays come with an RT/Duroid 5880 substrate and are constructed using an E-shaped MSPA. The frequency that was used for the design is 2.4 GHz. The substrate material has a thickness of 3 mm.

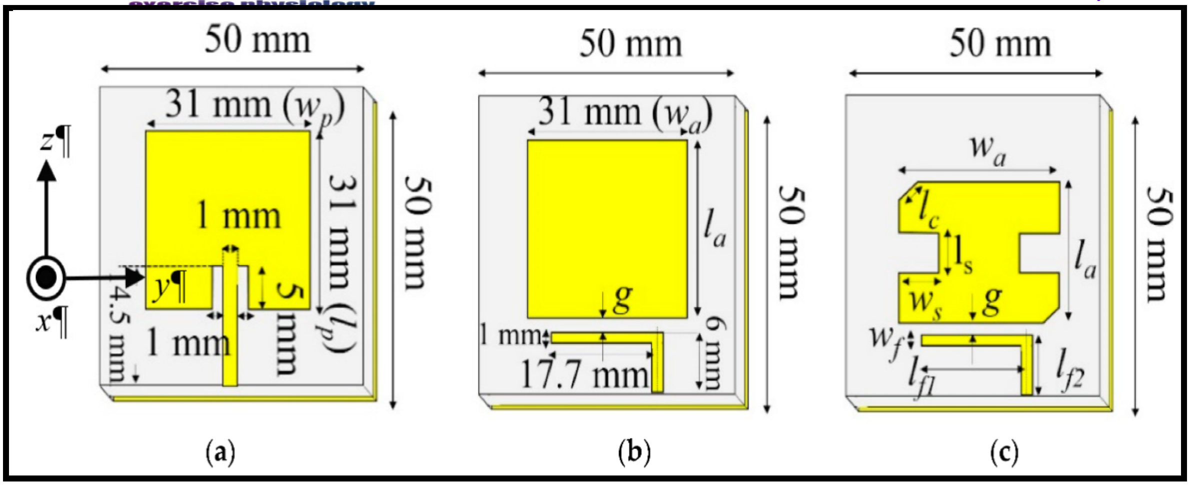
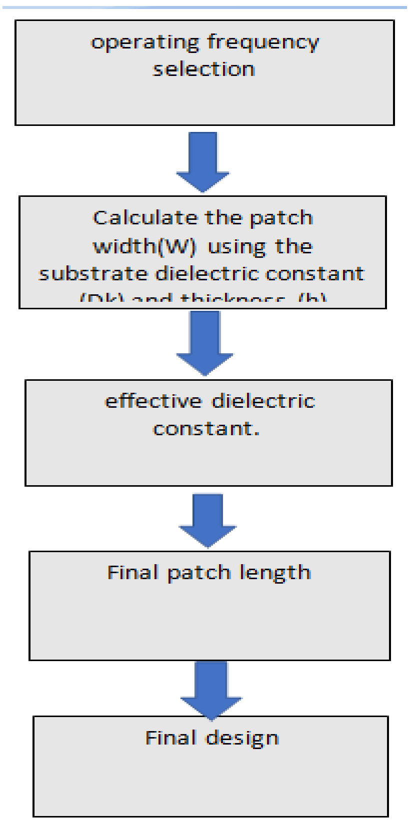


Fig 6 : Design methods of antenna

The design process goes as follows:



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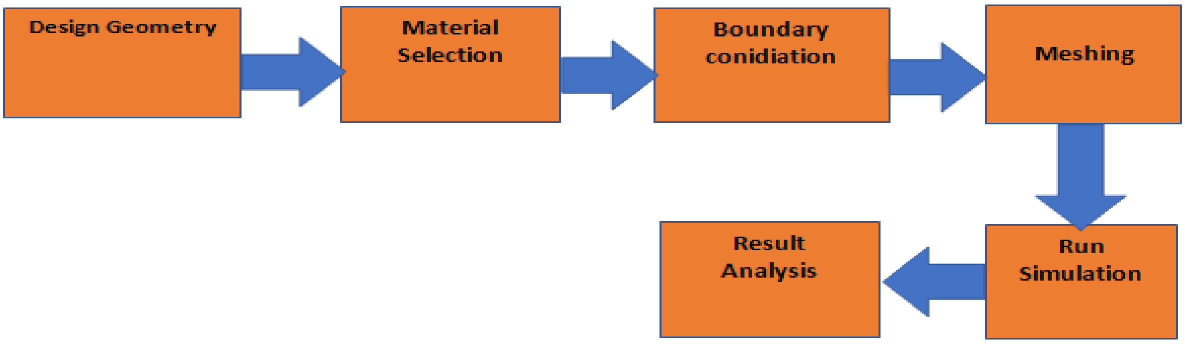
WORK FLOW :



5.Methodology

A microstrip patch antenna has to be designed and developed according to these stages. [13].

• The First Step: Make a Flat Surface

Length of the ground plane, measured in meters. Standardly, the x-axis is used to measure ground plane length. Antenna analysis is performed using the infinite ground plane approach when the 'Ground Plane Length' becomes Inf.

A scalar value in meters representing the breadth of the ground plane. The y-axis is the default for measuring ground plane width. The infinite ground plane approach is used for antenna analysis when the 'Ground Plane Width' is set to Inf.

The two-element vector indicating the signed distance from the center along the length and breadth of the ground plane. You may change the feed point's position in relation to the ground plane and patch using this attribute. In order to mesh the patch properly during analysis, be sure to position the feed just within its boundaries.

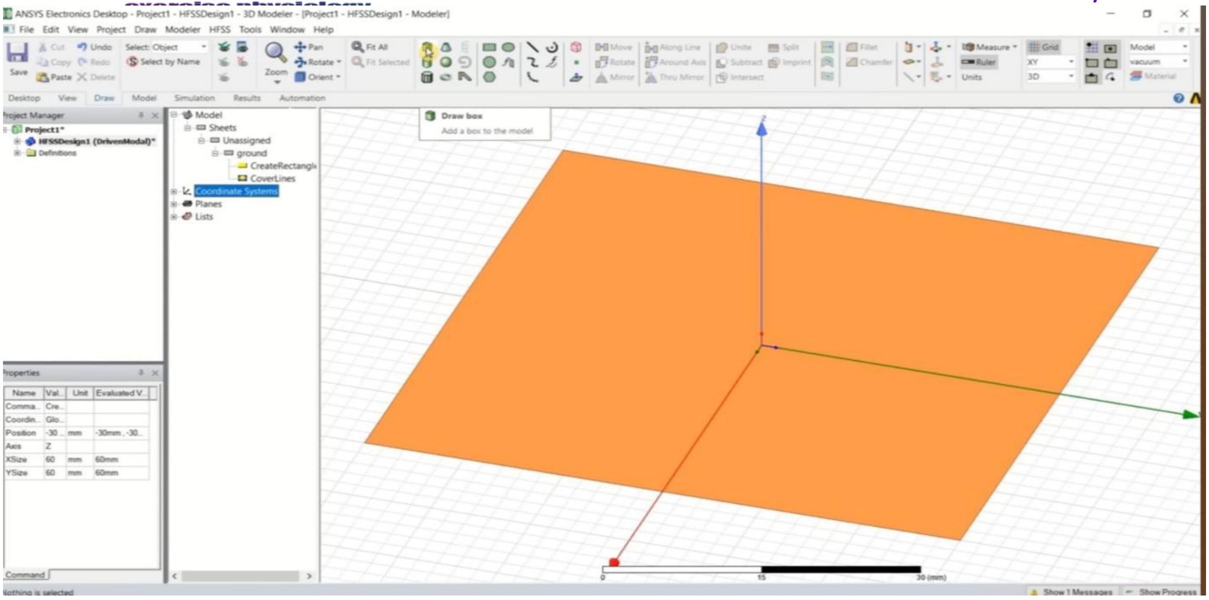
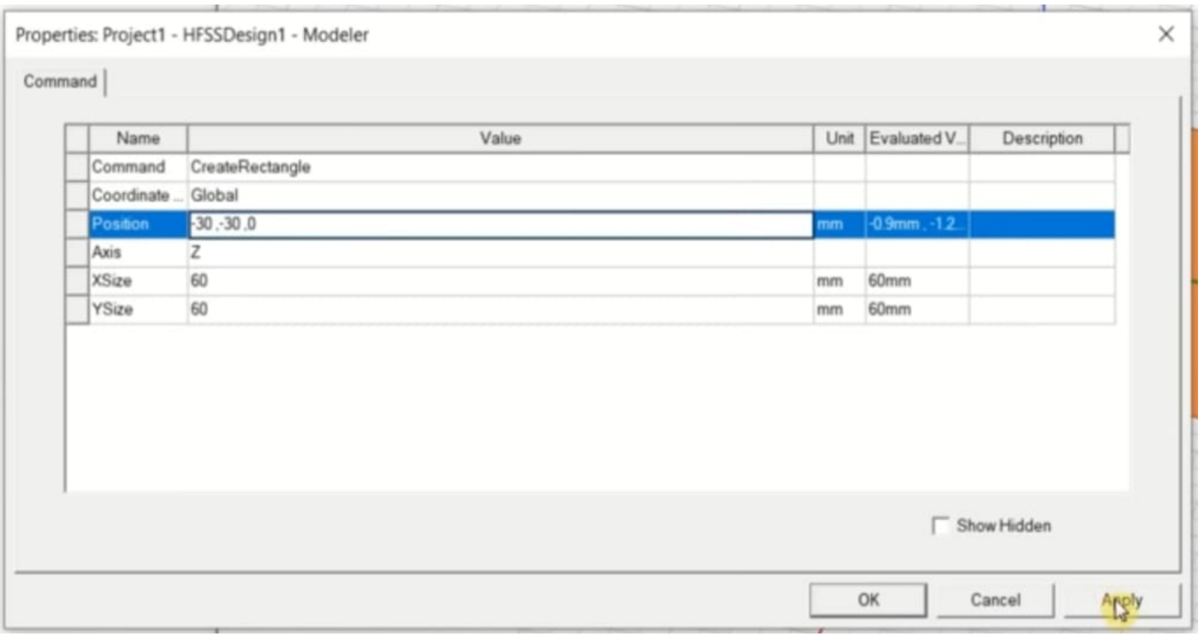


Fig 7 : Design a grund plane

A two-element vector in meters that specifies the distance from the center along the length and breadth of the ground plane. Make use of this attribute to change the patch's position in relation to the floor.

Measurements:


Properties: Project1 - HFSSDesign1 - Modeler

Command

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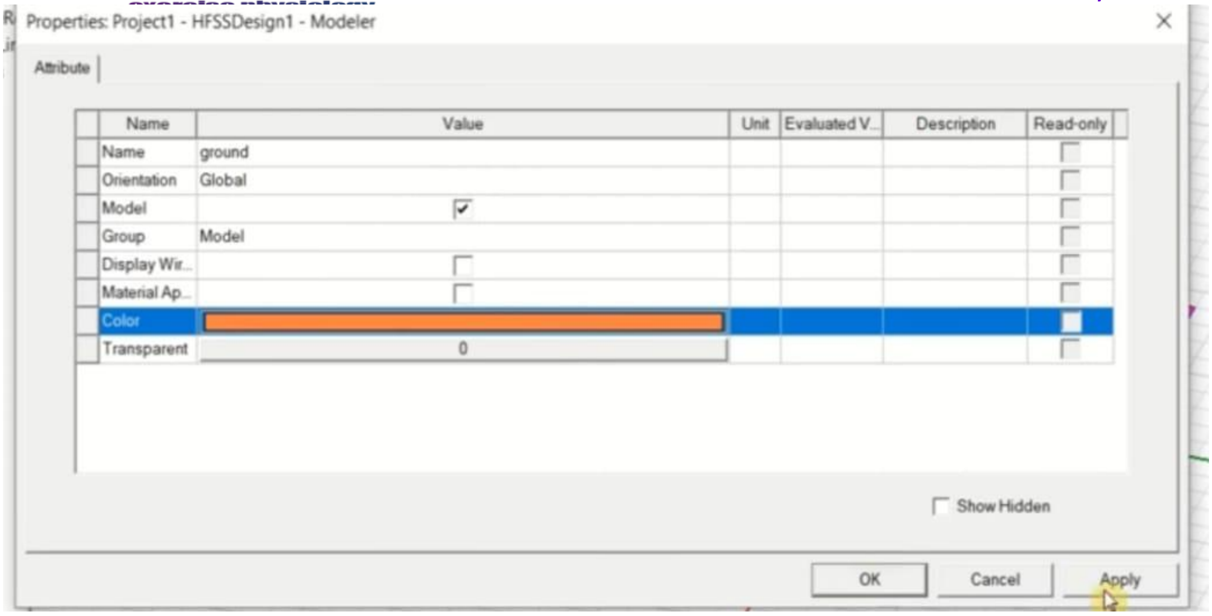

Fig 8 : assigning values of ground plane

Applications of FEM:

FEM finds widespread use in many domains, including but not limited to: aviation design, biomedical research (e.g., cranial surgery planning), civil engineering (e.g., structural modeling and analysis), electrical engineering, the aerospace industry, automobile manufacturing, and many more.

For the majority of analyses, the following steps are involved in developing a finite element model (Baguley and Hose, 1997):

- **Selection of analysis type.**
- **idealization of material properties.**
- **Creation of model geometry.**
- **Application of supports or constraints.**
- **Application of loads.**
- **Solution optimization.**

Ansys Tools: (HFSS)

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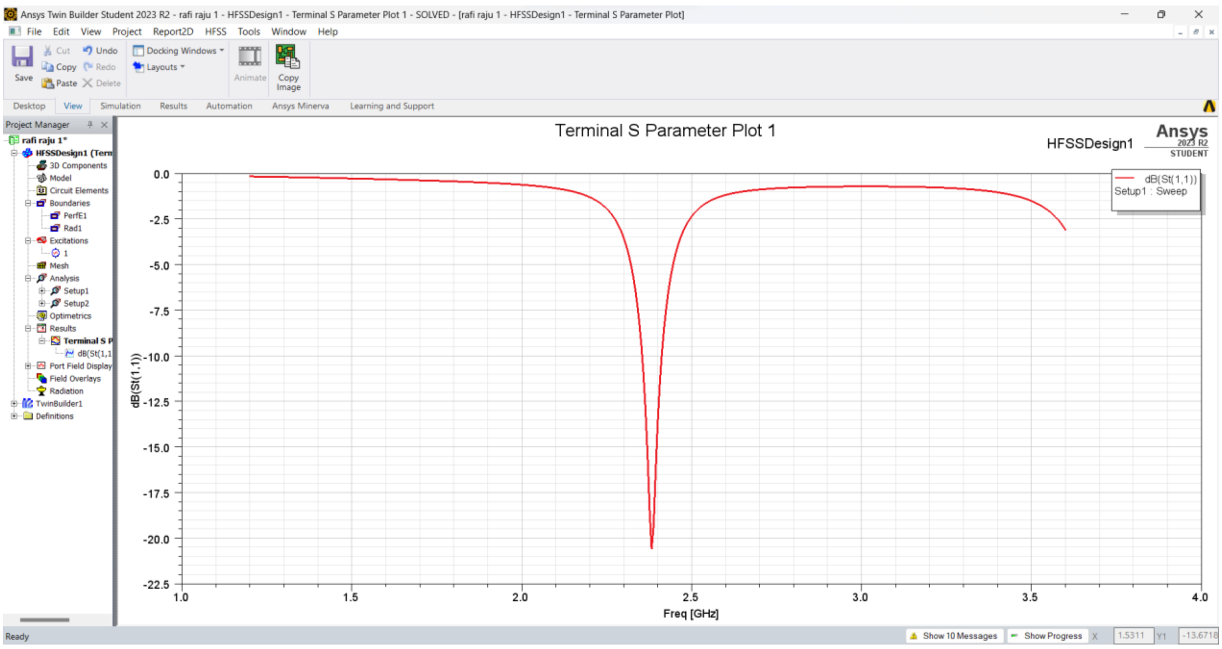
Among the many sophisticated solver choices available in Ansys Mechanical, a finite element analysis (FEA) program, users may do structural analyses using linear dynamics, non-linearities, thermal analysis, materials, composites, hydrodynamics, explicit, and many more.
With each adaptive mesh step and for each point in a frequency sweep, HFSS Mesh Fusion solves a completely linked electromagnetic matrix, allowing it to continue using the same "electromagnetically aware" adaptive meshing method without sacrificing accuracy.
Antenna filters, various microwave components, and more may all be designed with HFSS.
The exclusive technique of HFSS Mesh Fusion allows for the simulation of far more intricate designs with the same precision, accuracy, and dependability as Ansys HFSS. For this purpose, it employs targeted meshing methods within the same design that are suitable for the local geometry.

RESULT :

Return loss : The final results of the simulation confirmed that the setting was correct. The -10 dB baseline is perfect for wireless or mobile devices. For optimal performance, the antenna is set to the necessary frequency. Its operating frequency is 28 GHz, as is shown in. For this frequency, the measured return loss was -38.348 dB. The return loss of the antenna that was designed is described by the spareameter. This device is an ideal fit for 5G applications because to its very high return loss value of -38.348 dB at -10 dB.



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CONCLUSION :

An X band microstrip patch antenna operating at 10 GHz is detailed in this research. The microstrip patch antenna is first defined with respect to its construction, operating principles, and application regions. In order to create the antenna, HFSS, AWS, and MATLAB were used. This design's equations are broken down and described in detail. These equations were solved and the parameter values were obtained using the MATLAB software. Both the top and side views of the antenna are included in the schematic. The simulation part includes graphical representations of SII characteristics, input impedance, radiation patterns on the E and H planes, and antenna gain. Presented in a table are the parameters that were used in the design of the antenna. According to the simulation findings, the antenna performs as expected and satisfies the X Band design requirements.

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