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DESIGN AND SIMULATION OF MICROSTRIP PATCH ANTENNA FOR WEARABLE DEVICES

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Abstract--_ ln this current world of technology, wireless communication through variable devices is becoming more popular everyday. In this paper, a microstrip antenna design, simulation , and analysis are done. And to make this design , Rogger RT/Duroid 5880, whose dielectric permitivity is 4.3, has been used as the substrate material. Besides, antenna thickness and tangent loss are 0.1 mm and 0.035, repectively. After simulation, the antenna has a return loss VSWR, directivity gain, and bandwidth are -19.89 dB, 1.22, 6,73 dBi, and 128.9 MHz, respectively. The motive of this antenna is to reduce the S-parameter and get a standardVSWR.

1.INTRODUCTION

The use of a Microstrip antenna represents a significant advancement in wireless communication systems, effectively meeting the demands of the latest generation of wireless communication technology in line with current innovations. Microstrip antennas are being used in these systems because to their many benefits, including their lightweight nature, planar construction, and high cost-effectiveness. Nevertheless, the limited working bandwidth creates a constraint on its use in wireless systems. Broadband applications, which handle a range of functions, and wireless devices have become essential components of our daily communication. Consequently, the need for a low-profile wideband has been reduced. The employment of microstrip antennas fulfills most of the criteria for mobile and satellite equipment, and it also suits other commercial needs. The size of electrical circuits needed for wireless applications is significantly decreasing, and the microstrip is very ideal for this purpose. The size of the antennas utilized for most applications is also significantly decreasing. The design of the microstrip antenna is tailored to meet specific requirements. Various methodologies have been examined, and it has been determined that enhancing the impedance bandwidth of the microstrip antenna may be a contributing factor to its enhancement. The phenomenon of notches and slots creating a carving effect has been extensively documented in several research, indicating its widespread occurrence. A rudimentary version of the Microstrip antenna may be created by using a dielectric substrate as the foundation material and etching a conducting material on the top surface of the substrate. Microstrip patch antennas are now prevalent because of their lightweight construction and compact size, which result in a limited frequency range and modest amplification.

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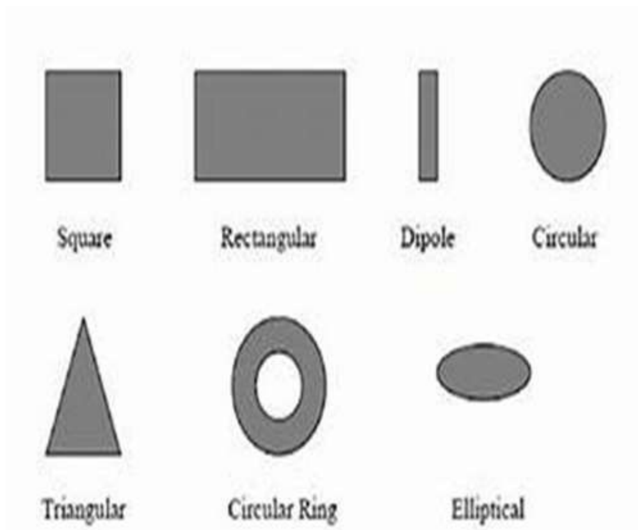
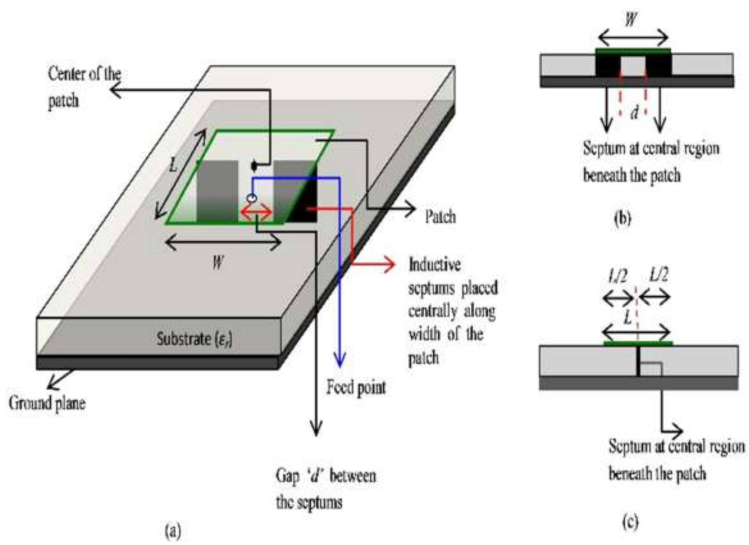


Fig: Design and Simulation

A metal patch makes up a significant portion of an microstrip patch antenna. The microstrip patch antenna sends and receives microwave frequencies of electromagnetic radiation.



The performance of a microstrip patch antenna depends on its length, width, substrate thickness, the dielectric constant of the material that makes up substrate, and where the feed line is placed. Microstrip Patch antennas have different shapes such as rectangle, square, circle, triangle, dipole etc. Figure 1 shows different shapes of antennas.

Microstrip patch antennas are increasingly essential in today's wireless communication systems. Various antennas exist, including folding dipole, slot, patch, and parabolic reflector antennas. There are many different kind of antennas, and each one made for a specific job and has its own features.

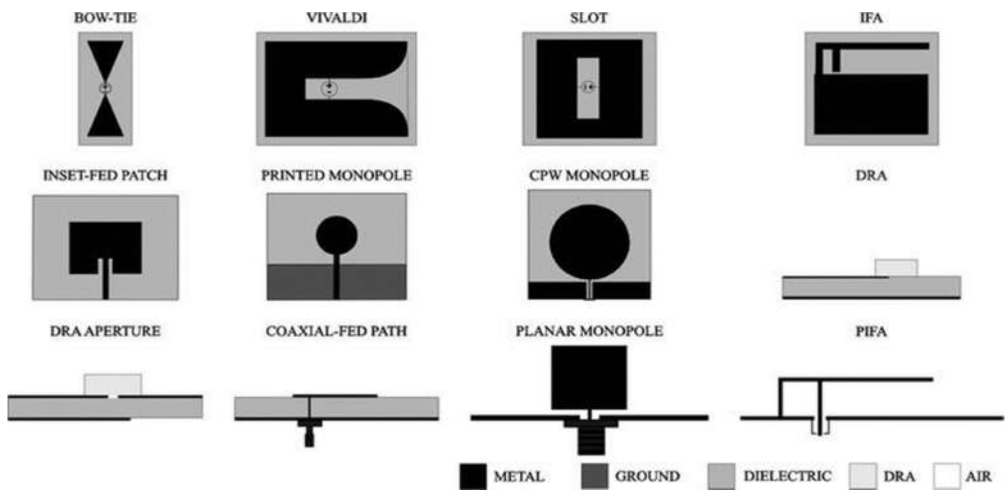


Fig: : Fractal and Polar Microstrip Antennas

2.Structure and Characteristics

Microstrip antenna structures are divided into four main parts i.e, ground plane, dielectric substrate, patch and feeding line. Ground plane is etched on the bottom side of dielectric substrate and conducting in nature. There are various dielectric substrates which are used for designing of this antenna and the value of dielectric constant generally used ranges . This paper is targeted at publishing channel characterizations within the 3.55 GHz band. The antenna should be small enough to work with new small speech devices. The goal is to have a high advantage and performance so that the original records can switch in any wireless communication space .

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: 2.1 Characteristics of Microstrip patch Antenna

To better organize the content that has been presented, this work has been split into five parts. Also, the first part is an introduction, the second part is a review of the relevant literature, the third part is about materials and methods, the fourth part is about designing and simulating antennas, the fifth chapter is an analysis of the results, and the sixth chapter is the conclusion.

2.1 Wearable Devices :

Wireless body area networks are being widely used due to the increase in the use of wireless networks and various electrical devices. A Wearable Patch antenna is used for enhancement of various applications for WBAN. In this paper, a low profile wearable microstrip patch antenna is designed and suggested for constant observation of human vital signs such as blood pressure, pulse rate and body temperature using wireless body area network (WBAN) technology. The operating frequency of the antenna is taken as 2.45 GHz which lies in industrial, scientific and medical (ISM) frequency band. Polyester textile fabric with a relative permittivity of 1.44 and thickness of 2.85 mm is used as a substrate material. The proposed antenna is designed to achieve better return loss, VSWR, gain and low value of specific absorption rate (SAR) as compare to other existing wearable antenna. The achieved antenna return loss at 2.45 GHz is about -10.52 dB and gain of 7.81 dB. The VSWR value achieved at 2.45 GHz is 1.84, which is good in terms of good impedance matching. Other antenna field parameters like 2D and 3D gain, radiation pattern, and SAR value have been calculated. High-Frequency Structure Simulator (HFSS) is used to design and simulate the proposed antenna.

2.2 **5G**

5G technology has been in development phase. The main reason behind it is, rapid increase in mobile traffic. This increases the demand for high data rates and bandwidth. To solve this problem, MIMO (Multiple Input, Multiple Output) is used. MIMO provides higher data rates with improved spectral efficiency and channel capacity by using the multipath property without changing the input power. High element isolation and broadband should be possessed by MIMO. The range targeted by 5G is 3–300 GHz, which can further help to provide higher data rates with wide bandwidth. The reason behind the range is also that the lower spectrum is already used by many wireless technologies and the higher spectrum is not utilized and could be used for 5G applications. When the higher spectrum is used, the challenge of free space propagation of higher frequencies arises. These frequencies provide the low coverage area but the problem can be solved by the frequency reuse property.

Fig 2.2 5G microstrip patch antenna

2.3 Objectives :

Due to miniaturization and advance FC Fabrication technology , it's a highly demanding field to fabricate the microantenna on PCB for wearable devices. So our approach is to design and simulate miniaturized patch antenna by using advance developed nanocomposite material which provides enhanced dielectric constant / strength. The dielectric factor related to size and radiation of the operating frequency of the antenna . we have used a glassy epoxy Nanocomposite of a material.

3.Literature Survey :

Over the years, several studies have been done on microstrip patch antennas. High-gain antennas send more power to the receiver, which is one of the problems. This is done to make the signal that is received stronger. Due to their reciprocity, high-gain antennas can also increase the strength of received signals by 100 when transmitting. Due to their directivity, directional antennas deliver fewer signals from directions other than the main beam. This characteristic lessens interference. With this method, wireless communication can have a high gain, which means that data can be sent at a much higher power level than in previous research.

Swarna et al. [4], a new slot-loaded microstrip patch antenna with a ground modification that looks like a helipad as a solution for the lower frequency spectrum of the 5G network, around 3 GHz. The antenna performs its function at the resonance frequency located inside the S-band. The simulation came up with a bandwidth of around 1.78 GHz, almost eighteen times greater than a standard MPA with a full ground plane. This increase comes as a result of the MPA's higher capacity. Both the current and proposed MPAs have radiation patterns that are not spherical and go in both directions. The proposed MPA has a radiation pattern that works in both directions and could be used for beamforming, wireless local area network (WLAN), and communication between satellites, among other things.

Bae and Yoon [15] proposed, an S-/Ka-band shared-aperture antenna has been proposed for use in 5G applications in this particular piece of research. This paper has been made by putting sixteen Ka-band slotted cavity antennas inside an S-band thick patch. This has resulted in the antenna array's increased bandwidth. A separate coaxial cable feeds each part of the slotted cavity antenna within the Ka-band. Within the framework of the TPCSCA, an S-band driving frequency microstrip-fed slot has been added. The experiments proved that the idea was correct, and it is expected that this will improve how well 5G dual-band applications use the aperture.

4.Design and Material Selection

The physical dimensions of the structures and the properties of the materials used to build them dictate how the MPA is carried out. In this consideration, a fixed rectangular shape is used because it is easy to make and look at. Also, compared to other types of receiving wire, it has a faster impedance transfer speed because it is more extensive.

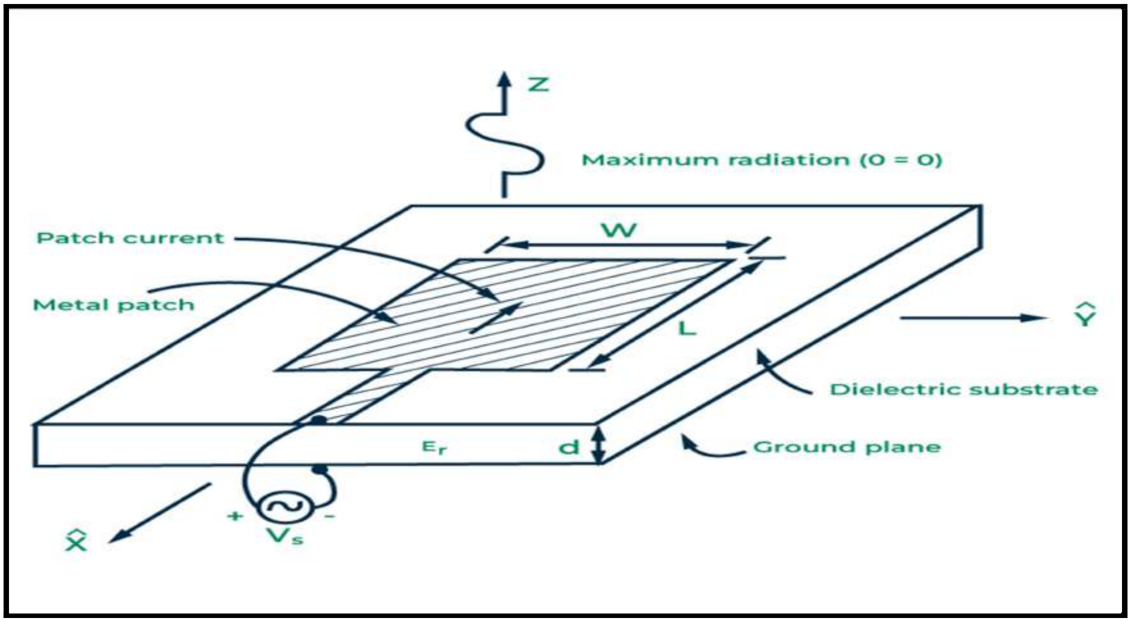


Fig 4.1: Design architecture of Microstrip Patch Antenna

The capacitance effect of a conductor placed in or around insulation material changes how an electromagnetic wave moves through it. This effect estimates how much a conductor's capacitance effect changes how an electromagnetic wave moves through it.

The entire viability of the receiving wire is affected by the dielectric constant. Length, characteristic impedance, and width all affect the reverberation frequency, which lowers the transmission rate and lengthens the time it takes for reverberation to happen again. The dielectric field includes controlling the adjacent area, the primary radiation source in microstrip fix receiving wires, and the dielectric consistency.

The borders will be more extensive and the radiation will be way better with lower esteem of driving to upgraded transmission capacity and productivity. The bordering field, which is the essential source of radiation in microstrip fixed radio wires, is additionally controlled by the dielectric steady.

4.1 Design :

The 2 × 2 and 3 × 3 antenna arrays are designed with an E-shaped MSPA with an RT/Duroid 5880 substrate. The design frequency is 2.4 GHz. The thickness of the substrate material is 3 mm.

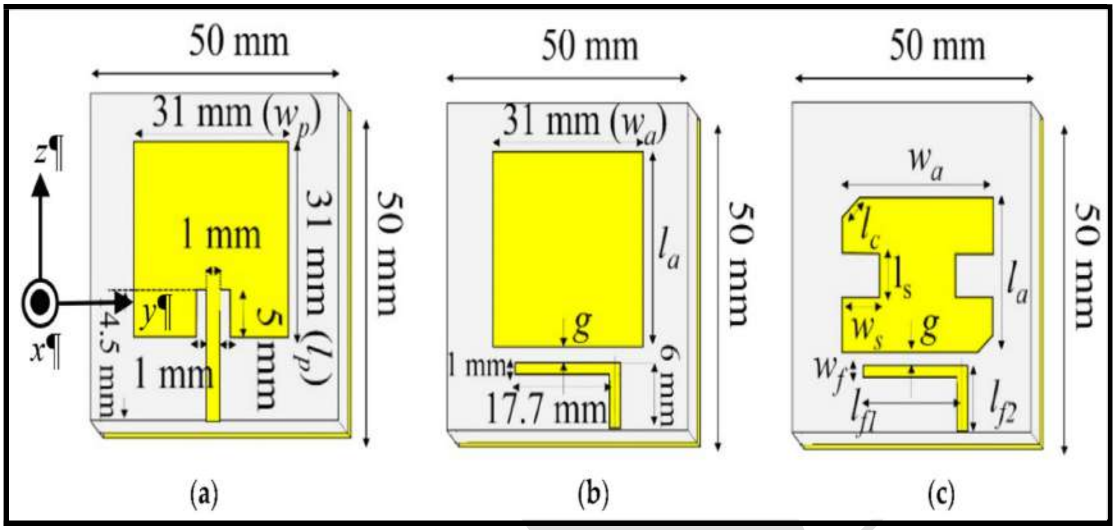


Fig 4.1: Design methods of antenna

The design process goes as follows:

operating frequency selection

↓

Calculate the patch width(W) using the substrate dielectric constant (Dk) and thickness (h)

↓

effective dielectric constant.

↓

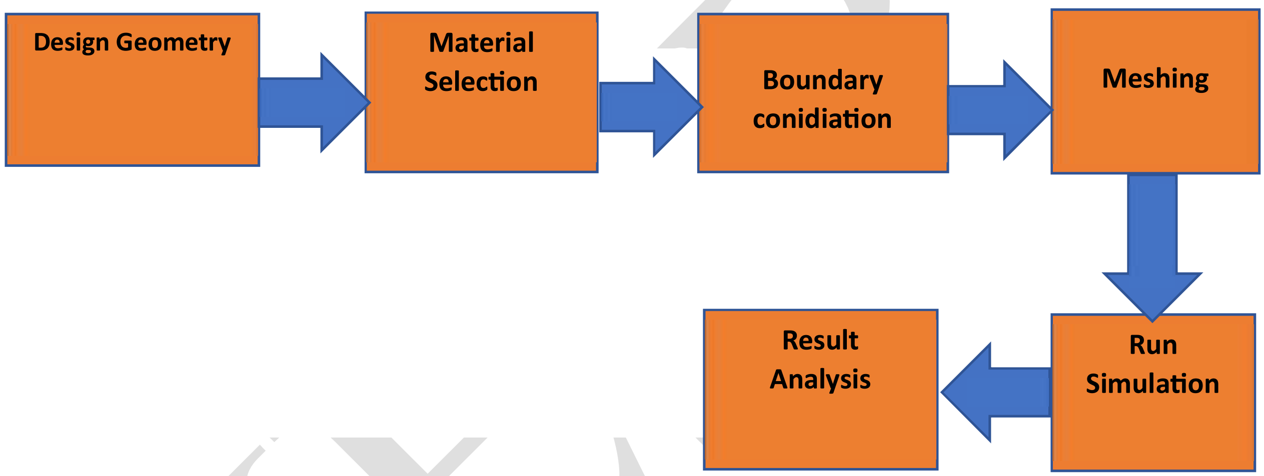
Final patch length

↓

The performance of a microstrip patch antenna depends on its length, width, substrate thickness, the dielectric constant of the material that makes up substrate, and where the feed line is placed. Microstrip Patch antennas have different shapes such as rectangle, square, circle, triangle, dipole etc. Figure 1 shows different shapes of antennas.

Microstrip patch antennas are increasingly essential in today's wireless communication systems. Various antennas exist, including folding dipole, slot, patch, and parabolic reflector antennas. There are many different kind of antennas, and each one made for a specific job and has its own features.

WORK FLOW :



5.Methodology

The following steps are proposed to be used while designing and developing a microstrip patch antenna. [13].

- Step I. Create Ground plane

Ground plane length, specified as a scalar in meters. By default, ground plane length is measured along x-axis. Setting 'Ground Plane Length' to Inf, uses the infinite ground plane technique for antenna analysis.
Ground plane width, specified as a scalar in meters. By default, ground plane width is measured along y-axis. Setting 'Ground Plane Width' to Inf, uses the infinite ground plane technique for antenna analysis.
Signed distance from center along length and width of ground plane, specified as a two-element vector. Use this property to adjust the location of the feed point relative to ground plane and patch. Place the feed sufficiently inside the edges of the patch to successfully mesh it during analysis.

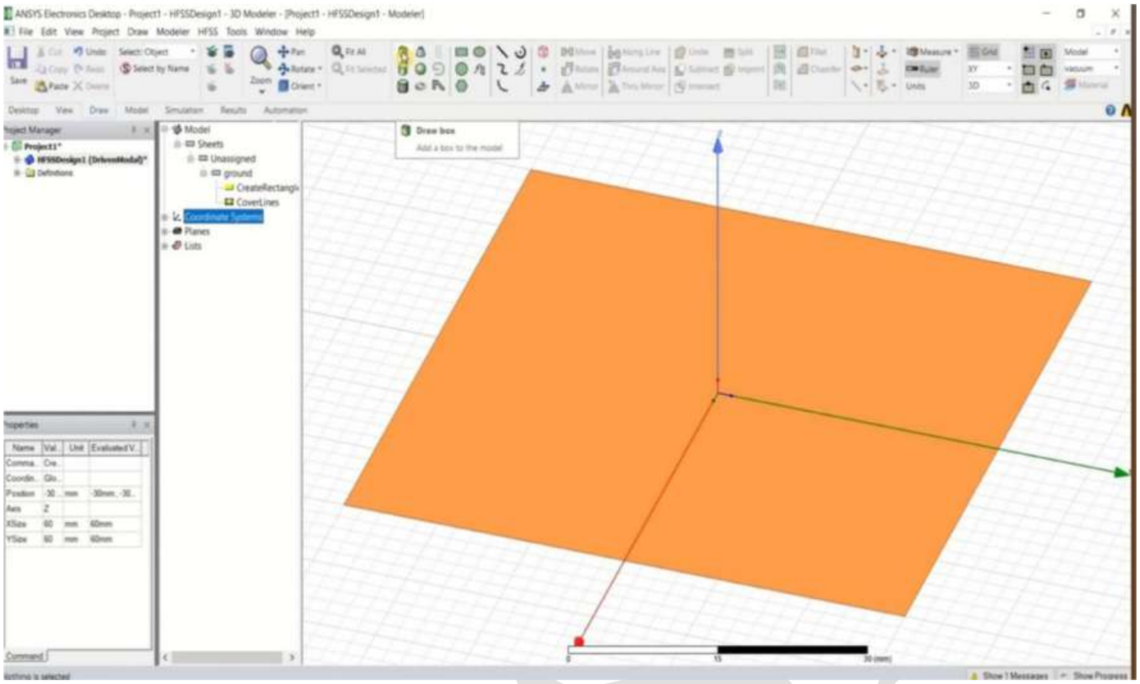
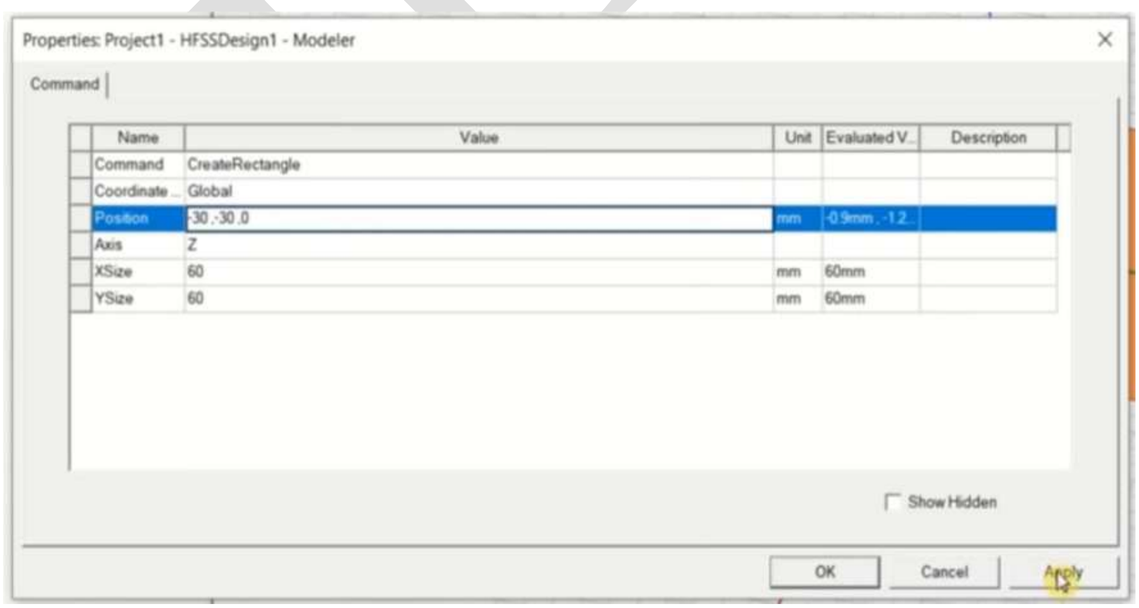


Fig 4.1 : Design a grund plane

Signed distance from center along length and width of ground plane, specified as a two-element vector in meters. Use this property to adjust the location of the patch relative to the ground plane.

Measurements:



Properties: Project1 - HFSSDesign1 - Modeler

Command

Name	Value	Unit	Evaluated V...	Description
Command	CreateRectangle			
Coordinate ...	Global			
Position	-30 ,-30 ,0	mm	-0.9mm , -1.2...	
Axis	Z			
XSize	60	mm	60mm	
YSize	60	mm	60mm	

Show Hidden

OK Cancel Apply

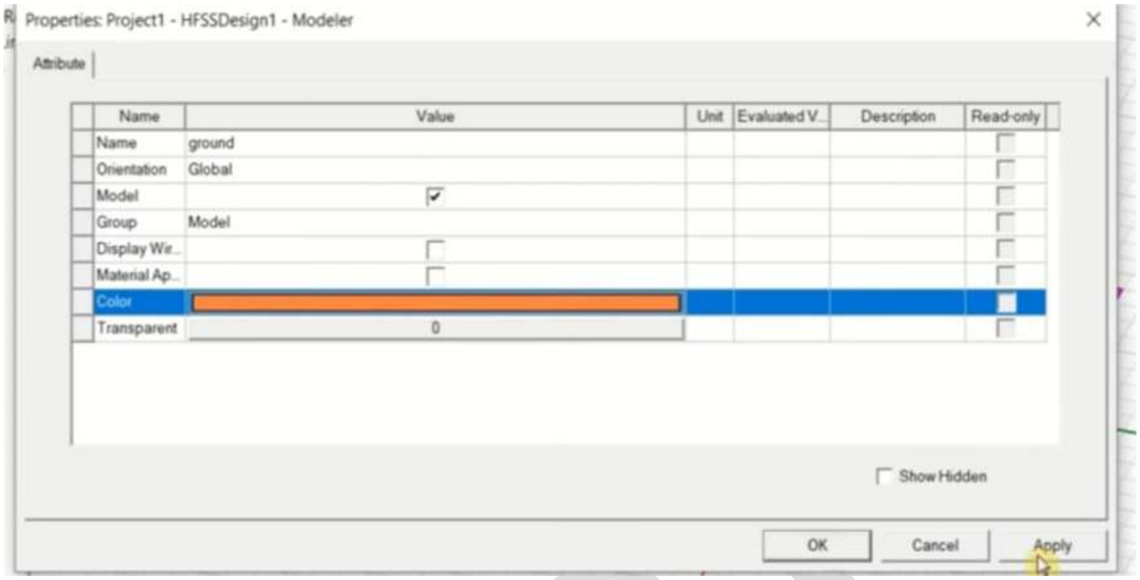


Fig 4.2 : assigning values of ground plane

Applications of FEM : FEM is extensively used in various fields such as aircraft design, biomedical research (like planning cranial surgery), civil engineering (modeling and analysis of structures), automotive industry, electrical engineering, aerospace industry and others.

The major stages in the creation of any finite element model, according to Baguley and Hose (1997), for most types of analysis are:

- **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)

Ansys Mechanical is a finite element analysis (FEA) software used to perform structural analysis using advanced solver options, including linear dynamics, Non-linearities, thermal analysis, materials, composites, hydrodynamic, explicit, and more.

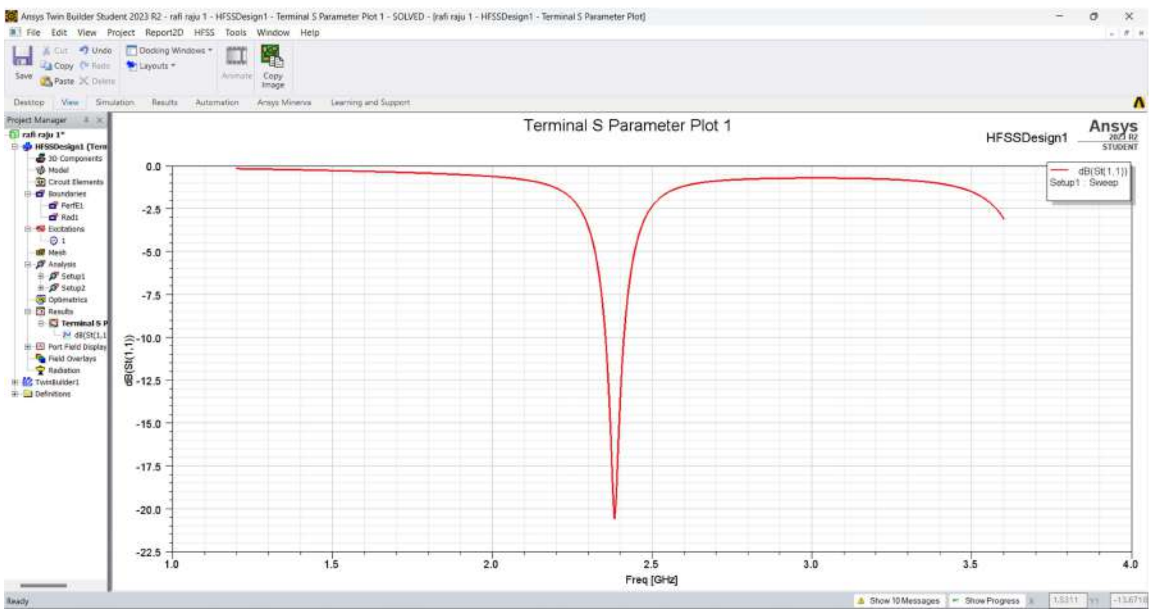
HFSS Mesh Fusion continues to use the same "electromagnetically aware" adaptive meshing technology as before without compromising accuracy because a fully coupled electromagnetic matrix is solved with each adaptive mesh step and for each point in a frequency sweep.

HFSS – We can design Antenna Filters, Different microwave components….etc

HFSS Mesh Fusion's patented technology enables much more complex designs to be simulated with the same rigor, accuracy and reliability of Ansys HFSS. It accomplishes this by applying targeted meshing technologies within the same design, appropriate to the local geometriate to the local geometry

RESULT :

Return loss : The parameter was determined to be accurate based on the simulation's final results. The base value is -10 dB, which is ideal for mobile or wireless technology. The antenna is tuned to the required frequency to function properly. As can be seen in it runs at a frequency of 28 GHz. At this frequency, the return loss was measured to be -38.348 dB. S parameter describes the return loss of the designed antenna. the value of the return loss at -10 dB is -38.348 dB which is very high ensuring perfect candidate for 5G applications.



CONCLUSION :

In this study, the design of a microstrip patch antenna at 10 GHz frequency for X band applications is explained. First of all, the usage areas, structure and working principles of the microstrip patch antenna are explained. HFSS, AWS and MATLAB programs were used in the antenna design. The equations used in this design are explained one by one. Using MATLAB program, these equations were solved and the values of the parameters were found. The schematic drawings of the antenna are given from the top and from the side. In the simulation section, SII characteristic graphics, input impedance graphics, E and H plane radiation patterns and antenna gain graphics were drawn. The parameters used in the antenna design are presented in a table. Simulation results show that the antenna works as desired and meets the X Band design criteria.

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