Compact Dual-band Microstrip patch antenna for Wifi/WiMax Applications

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Abstract-Dual-band microstrip patch antennas have emerged as a hot issue, with the goal of addressing the fundamental constraints of a traditional antenna, such as antenna size and restricted bandwidth. It is made up of a radiating patch on one side of the dielectric substrate and a ground plane on the other. When compared to traditional antennas, antennas provide appealing properties like as gain, **polarization**, and system capacity. In this project, a linear **polarized** micro strip antenna is constructed using the microstrip feed technique in the S(2.5-4.5GHz) and C(3.6-5.3GHz) operating bands (1.01-3.6GHZ).The influence of all essential geometric antenna characteristics has been thoroughly considered and **optimized** using an HFSS simulator. The suggested antenna is **characterized** by dual band functioning in conjunction with linear **polarization**.

Keywords:*Dual band Microstrip antenna, microstrip feed, Linear polarization, Wi- Fi and Wi-Max applications*

INTRODUCTION

As wireless communication applications expand, new issues in antenna design and operation have emerged. **Dual band** microstrip patch antennas have been a popular issue in the research with the aim of overcoming the fundamental flaws of traditional patch antennas with microstrips, such as poor gain, low efficiency, confined bandwidth, and insufficient power handling capabilities. Along with compactness, multiple frequency operating is increasingly becoming a need. Although the rectangular patch antenna is smaller, its bandwidth has greatly enhanced. The decreasing value of the Quality factor is the justification for achieving greater bandwidths (Q). Figure 1.1 depicts a rectangular microstrip patch antenna with the following dimensions: L, W, and H. (h). The length is selected to be in the x direction, the height is selected to be along the z direction. The width is selected to be in the y direction.

LITERATUREREVIEW

A Dual-band Microstrip Patch Antenna for Mobile WiMAX, WLAN, Wi-Fi, and Bluetooth Applications: Design and Performance Analysis:

Authors**:** Ibnul Sanjid Iqbal, Moinul Hossain, and Md. Ashikur Rahman the CST Microwave Studio is used to build and simulate a dual band microstrip patch antenna. Due to its extremely tiny size and light weight, the suggested antenna may be integrated into mobile devices for mobile WiMAX, Wi-Fi, Bluetooth, and WLAN operations. The proposed antenna covers over 90% of the Mobile WiMAX working spectrum with a broad bandwidth of 180 MHz at 2.5 GHz and an ultra-wide band at 5.8 GHz (frequency range 2.5–2.7 GHz). The gain, directivity, return loss, and VSWR parameters of this antenna are excellent. It may be applied to WiMAX, Wi-Fi, Bluetooth, and WLAN applications in mobile devices.

For Wi-Fi and WiMAX Applications, Compact Dual Band Microstrip Patch Antenna:

Authors**:** Amal K. A., Subin Joseph, and Sreekumari Amma at the Wi-Fi (5.3 GHz) and WiMAX (3.6 GHz) bands, offset feed is employed to accomplish impedance matching and diagonal edge cutting generates numerous resonances. At WiMAX and Wi-Fi frequencies, the suggested antenna in this work has an acceptable radiation pattern with gains of 1.01 dB and 2.9 dB, respectively.

I. OBJECTIVES

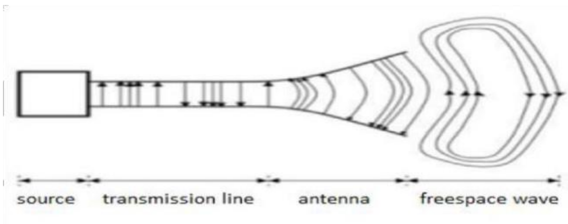
The project's primary goals are:

- The main goal of this project is to use HFSS software to construct a Microstrip patch antenna for Wi-Fi/WiMAX applications.
- To research and evaluate the patch antenna's specifications and features.

II. FUNDAMENTALS OF THE PROJECT

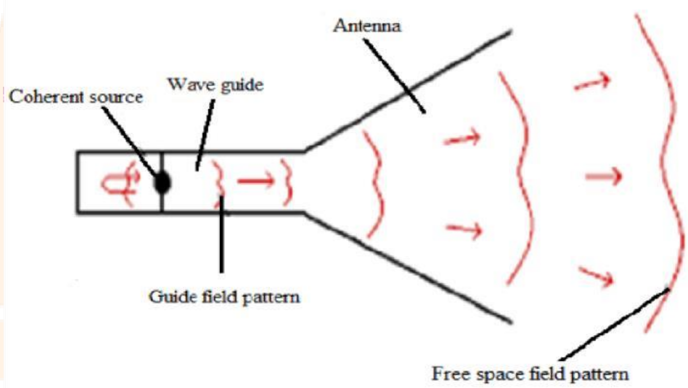
WHAT IS ANTENNA?

A transducer is a device that converts a directed wave into a radiated wave or the other way around. The coaxial cable connecting to the antenna is the most glaring example of the structure that "guides" the energy to the antenna. The radiation pattern of the antenna identifies the energy that is emitted. Antennas play a crucial role in communication networks. A device used to convert an RF signal travelling on a conductor into an electromagnetic wave in free space is known as an antenna.
Depending on whether it is being used for receiving or sending, an antenna is a device for converting electromagnetic radiation in space into electrical currents in conductors, or vice versa. Receivers are passive radio telescopes. Calculating the characteristics of transmitting antennas is often simpler. Fortunately, when an antenna is utilised for receiving, many of its properties—such as its emission pattern—remain unaltered. An antenna is a metallic component used to transmit or receive radio waves (it might be a rod or wire). It is a component of a circuit that allows a guided wave on a transmission line to change to a free space wave. It also makes electromagnetic energy gathering possible.
A transmitting antenna connected to atransmitter by transmission forces electromagnetic waves into free space which traveling space with velocity of light Similarly, are receiving antenna connected to a radio receiver, receives, or intercepts a portion of electromagnetic waves travelling through space. The guiding device or transmission line may take the form of a coaxial linear a hollow pipe(waveguide), and it is used to transport electromagnetic energy from the source to the antenna or from the antenna to the receiver.



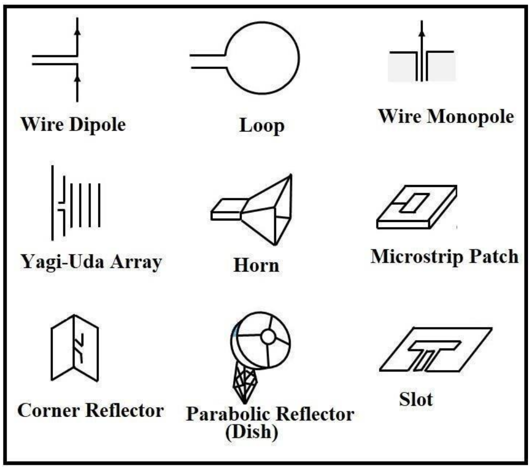
A figure of merit for an antenna in electromagnetics is directivity. It compares the power density emitted by the antenna's greatest emission to the power density radiated by an ideal isotropic radiator (which emits evenly in all directions) emitting the same amount of power. The other element of an antenna's gain is its (electrical) efficiency, and directivity is one of those two. Since most emissions are meant to travel in a certain direction or at the at least in a specific plane (horizontal or vertical), directivity is a crucial parameter to consider. In contrast, emissions travelling in other directions or planes are wasteful (or worse). When an antenna emits radiation in a certain direction, its directivity.

By altering the current flow inside a conduction wire, an antenna radiates. by changing the current in a straight wire over time. The straight wire won't radiate if there is no flow motion or if the current flow is uniform. Even if the wire moves at a constant speed, bending it will cause the current flow to accelerate, which will cause the wire to radiate. An antenna is shown radiating in the illustration above. Antennas come in a variety of forms, including dipoles, helices, paraboloids, stubs, whips, and more. The radiation pattern of an antenna is significantly influenced by its form. A variety of important factors, including as bandwidth, beamwidth, directivity, efficiency



TYPES OF ANTENNAS

At Future Electronics, a variety of antenna types are offered. The most prevalent varieties are divided into several categories based on characteristics including operation frequency, power handling, gain, operating temperature range, and type.s



ANTENNA PARAMETERS

We employ a variety of factors, some of which are connected to one another, todefine an antenna's performance. These are:

AntennaGain:

The ratio of the intensity in each direction to the radiation intensity that would be achieved if the power absorbed by the antenna were radiated isotopically is known as the gain of an antenna (in each direction). The power accepted (input) by the antenna divided by 4 gives the radiation intensity that corresponds to the isotopically radiated power.

Most of the time, we deal with relative gain, which is calculated as the difference between the power gain of an antenna used as a reference and its own power gain in the direction in question. Both antennas must get the same amount of power. The reference antenna is often a dipole, horn, or other known or calculable gain antenna. However, the reference antenna is often an isotropic lossless source.

AntennaEfficiency

According to IEEE Std 145-1993, "Standard Definition of Terms for Antennas," antenna efficiency is "The ratio of the total power radiated by an antenna to the net power taken by the antenna from the linked transmitter." It is depending on frequency and is occasionally given as a percentage (less than 100).

To account for losses at the input terminals and inside the antenna's construction, the overall antenna efficiency, or e0, is utilised.

$$\eta = \frac{P_{rad}}{P_{in}} = \frac{P_{rad}}{P_{rad} + P_{loss}} = \frac{R_{rad}}{R_{rad} + R_{loss}}$$

Where:

η=antennaefficiency(%)

$Prad$=radiatedpower(W)

$Ploss$=powerlossduetoresistiveloss(W)

Pin=totalpoweravailabletoantenna(W)

$Rrad$=radiatedequivalentresistance(Ω)

$Rloss$=equivalentlossresistance(Ω)

$$e_0 = e_r e_c e_d$$

$e0$isduetothecombinationofnumberofefficiencies.

$e0$=totalefficiency,

er=reflection,

ec=conductionefficiency

ed=dielectricefficiency

$$e_r = (1 - |\Gamma|)^2$$

Antenna Effective Area:

In the theory of electromagnetics and antennas. A measurement of an antenna's capacity to receive radio waves is its aperture of effective area. The region perpendicular to an incoming wave's direction that would be able to block the same amount of energy as the antenna that is receiving it is known as the aperture.

Bandwidth:

An antenna's bandwidth is the range of frequencies within which its performance in terms of a certain characteristic complies with a given standard. The range of frequencies on either side of a center frequency—typically the dipole's resonance frequency—where the characteristics of the antenna, such as input impedance, pattern, beam width, polarization, side lobe level, gain, beam direction, and radiation efficiency, are within a reasonable range of the center frequency can be referred to as the bandwidth. The bandwidth of broadband antennas is often stated as the ratio of the upper to lower operating frequencies. In terms of radiation patterns or VSWR/reflected power, bandwidth may be described. According to VSWR. Since the percent bandwidth is constant with respect to frequency, bandwidth is frequently stated as a percentage. If bandwidth is measured in absolute frequency units

$$BW = \left[\frac{f_{r2} \pm f_{r1}}{f_r}\right] \bullet 100(\text{percent})$$

Radiation Pattern:

A radiation pattern is the fluctuation in power radiated from an antenna when the antenna is not in use. A plot of an antenna's far-field radiation characteristics called the radiation pattern. the azimuth angle () and elevation angle (), which together define the spatial coordinates. It is a plot of an antenna's power output per solid angle, which is simply the radiation intensity.

A section of the radiation pattern that is surrounded by relatively modest radiation intensity is known as a radiation lobe. Several components of a radiation pattern are referred to as

Major Lobe (also called main beam): -The definition of the term "major lobe" (also known as "main beam") is "the radiation lobe containing the direction of highest radiation."

Minor Lobe: - Any lobe that is not a major lobe is a minor lobe.

Side Lobe: -The side lobe is the smaller lobe next to the larger lobe. "A radiation lobe in any direction other than the designated lobe" is what it is.

Back lobe: -Back lobe is the lobe directly across the main lobe. A radiation lobe with an axis that creates a roughly 180-degree angle with an antenna's beam is what that is.

- Minor lobes should be reduced since they often indicate radiation coming from undesirable directions.
- Of the minor lobes, side lobes are often the biggest.

Return Loss:

Return loss in communications refers to the loss of power in the signal that is reflectedor returned by a break in an optical fibre or transmission line. This break may be caused by a mismatch with the ending load. Pi is the incident power, Pr is the reflected power, and RL (dB) is the return loss in dB. Standing wave ratio (SWR) and reflection coefficient () both influence return loss. SWR decreases as return loss increases. A measure of how well devices or lines are matched is return loss. If the return loss is substantial, a match is good. Lower insertion loss is produced by a greater return loss, which is desired.

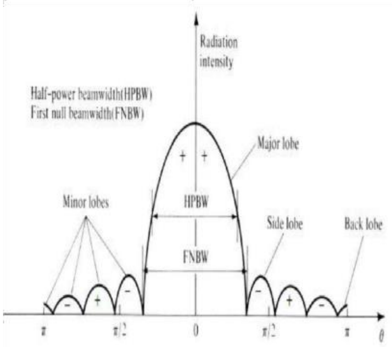
Beamwidth:

Beam width is a variable that is connected to an antenna's pattern. The angle between two identical locations on opposing sides of the pattern maximum is referred to as the beam width of a pattern.

function.

- An antenna's beam width is a crucial figure of merit that is frequently utilised to trade off with the side lobe level; that is, as the beam width reduces, the side lobe increases, and vice versa.

The ability of the antenna to differentiate between two nearby radiating sources or radar targets is also described by the beam width of the antenna.



Half-Power Beam width (HPBW):

The angle between the two directions where the radiation intensity is equal to one-half of the beam's value in a plane encompassing the direction of the beam's maximum.

First-Null Beam width (FNBW):

Angular distance between the pattern's initial nulls**.**

Input Impedance:

"The impedance provided by an antenna at its terminals," or "the ratio of the voltage to current at a pair of terminals," or "the ratio of the relevant components of the electric to magnetic fields at a location," are all examples of input impedance. the input impedance at a pair of terminals serving as the antenna's input terminal.

ZA=RA +jXA

where,

ZA=antenna impedance at terminals*a*–*b*(ohms).*RA* = antenna resistance at terminals *a* –*b* (ohms). *XA*=antennareactanceatterminals*a*–*b*(ohms).

VSWR(Voltage Standing Wave Ratio):

The impedances of the radio and transmission line need to be perfectly matched for a radio (transmitter or receiver) to provide power to an antenna. the variable the impedance matching of the antenna to the radio or transmission line to which it is attached is quantified using the VSWR metric. It gauges how well radio-frequency electricity is carried from a power source through a transmission line and into a load (for example, a television set).

S11 or return loss are other names for the reflection coefficient.

The VSWR for antennas is always a precise and positive figure. The antenna is more well matched to the transmission line and receives more power the smaller the VSWR. 1.0 is the VSWR minimum. This situation is optimal since there is no power reflected from the antenna. A bandwidth requirement is frequently specified for antennas in terms of VSWR.

for instance, from a power amplifier to an antenna through a transmission line). It is the ratio of a transmission line's highest radio frequency voltage to minimum radio frequency voltage. It comes from:

$$VSWR = \frac{V_{max}}{V_{min}}$$

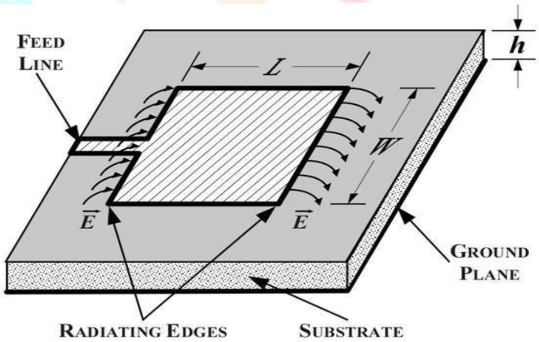
Once the reflection coefficient is known, the VSWR is determined using the formula below:

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$$

MICROSTRIP PATCHANTNENNA:

A conducting patch with a ground plane on the opposite side of a dielectric substrate makes up a microstrip patch antenna (MSA), which can have any planar or non-planar design. It is a well-liked printed resonant antenna for semi-hemispherical coverage narrow-band microwave wireless communications. The microstrip patch antenna has been extensively investigated and is frequently employed as a component of an array due to its planar structure and simplicity of integration with microstrip technology.

Up to now, several microstrip patch antennas have been



researched. There is a complete list of the geometries and their key characteristics.

The fundamental and most popular types of microstrip antennas are rectangular and circular patches. These patches are employed in both the most basic and complex applications. Rectangular geometries are naturally separable, and their analysis is straightforward. The symmetry of the circular patch antenna's radiation pattern is a benefit.

ADVANTAGES OF MICROSTRIP PATCH ANTENNA:

The performance, reliable construction, wide application, and sturdy design of Microstrip patch antennas are widely recognised. The benefits of this Microstrip patch antenna outweigh its drawbacks, which include its simplicity in design and light weight, among others. It has a variety of uses, including in satellites, satellite applications, satellite communications, and of course military systems like missiles, rockets, and aircraft.Due to its inexpensive cost of substrate material and production, microstrip antennas are being used extensively in many industries and regions and are now experiencing a boom in the commercial sector. Additionally, it is projected that when fixed radio wire usage increases for long distances, this will eventually take precedence over the use of conventional patch antennas for the most important applications. There are several methods for analysing microstrip patch antennas.

System	Application
Aircraft and Ship antennas	• Communication and navigation, altimeters blind landing system
Satellite communications	• Domestic direct broadcast TV, vehicle-basedantennas, communication
Mobile communication	• Pagers and hand telephones, man pack system,mobile vehicle
Remote sensing	• Large light weight apertures

METHODOLOGY

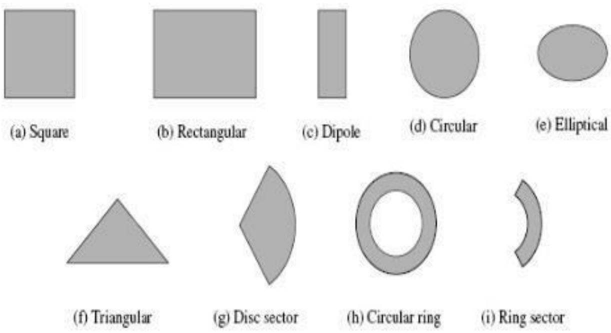
ARCHITECTURE OF PATCH ANTENNA

Wherever there are limitations on size, weight, cost, performance, and ease of installation, microstrip patch antennas are widely utilized. A metallic patch is etched into an electrically thin, grounded dielectric substrate in the basic arrangement. The substrate's thickness is considerably smaller. Typically, an imbalanced feed is used to asymmetrically feed the patch element. Patches are primarily measured in terms of their size in terms of a comparable operational wavelength.

As illustrated in Figure 5.1, the fundamental structure consists of a metallic patch etched on top of an electrically thin and grounded dielectric substrate. The substrate's thickness is considerably smaller. Typically, an imbalanced feed is used to asymmetrically feed the patch element. Patches are primarily measured in terms of their size in terms of a comparable operational wavelength.

- However, this arrangement results in a greater antenna size.
- Narrower bandwidth can be achieved by using higher dielectric constants, which areless effective.
- Narrow bandwidth in security systems is expected.

DIFFERENTSHAPE OF ANTENNA PATCH:



MICROSTRIP SUBSTRATE:

Although their effectiveness depends on the type of substrate material chosen for a printed-circuit board, microstrip lines are typically used in microwave circuits (PCB). The overall dielectric steady is one of the substrate's most important material barriers, and it should be understood before designing a microstrip-based circuit with high repetition rates. The method for determining the relative dielectric steady of a microstrip substrate considering relevant microstrip line experimental circumstances is given below. It is simple and effective. The thickness of the substrate layer is 0.01 to 0.05 free-space frequency. It is primarily used to provide legal dispersal and mechanical assistance between the fix and its ground plane.

S.NO	Dielectric substrate name	Dielectric Constant
1	FR4	4.4
2	RT Duroid-6002	2.2
3	RO4730	3
4	Rogers RO 3200	3.02
7	Foam	1

FEEDING TECHNIQUE

There are several ways to feed microstrip patch antennas. The two types of these techniques are contacting and non-contacting. In the contacting approach, a connecting component like a microstrip line is used to supply the RF power directly to the radiating patch. Electromagnetic field coupling is used in the non-contacting system to transmit power between the microstrip line and the radiating patch. The four most widely utilized feed methods are proximity coupling, aperture coupling, coaxial probe (both contacting schemes), and microstrip line (both non-contacting schemes). By direct or indirect contact, a feed line is utilized to stimulate to radiate.

CALCULATION OF DIMENSIONS AND FORMULAE USED

The following is the design process for a rectangular microstrip patch antenna at a certain frequency with an appropriate substrate material.

In the case of coaxial feeding, the origin should be the patch's centre, and the feed position will be shown as (Xf, Yf) from the origin. For the resonant frequency, a feed point on the patch with input impedance of 50 ohms should be chosen at a specific place.

1.The width of the antenna can be calculated using the equation

$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r + 1}{2}}} \quad ---$$

2.The effective dielectric constant can be calculated using the equation

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r + 1}{2}\left(1 + 12\frac{h}{w}\right)^{-0.5}$$

3.The effective length can be calculated using the equation

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

4.Active length is given by

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

5.Ground width and length are given by

$$L_g = 6h + L$$

$$W_g = 6h + W$$

DESIGN ANDSIMULATIONUSING HFSS

HFSSANDFEATURES:

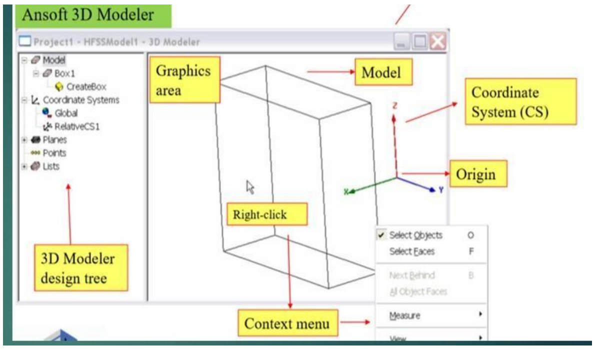
The term "High Frequency Structure Simulator" is referred to as HFSS. The industry standard for modelling 3-D full wave electromagnetic fields is Ansoft-HFSS software. Engineers creating high-frequency and high-speed electronics components must use it because of its industry-leading accuracy, sophisticated solver, and computational technology.

FeaturesofHFSSare:

1. Automatic Adaptive Meshing
2. Solver Technologies
3. Advanced Finite Element Method Technology
4. Mesh Element Technologies
5. Optimization and Statistical Analysis
6. EDA Design Flow Integration
7. High-Performance Computing

ANSOFTTERMINOLOGY

The following project information is contained in the HFSS Model:
Boundaries - Displays the boundary conditions associated with an HFSS design that describe the field behavior at the issue region and object interface boundaries.Excitation - This feature shows the excitations allocated to an HFSS design, which are used to specify the sources of charges, currents, and voltages on the design's objects and surfaces.
Mesh Operation - Shows the mesh operations chosen for an object or its faces.

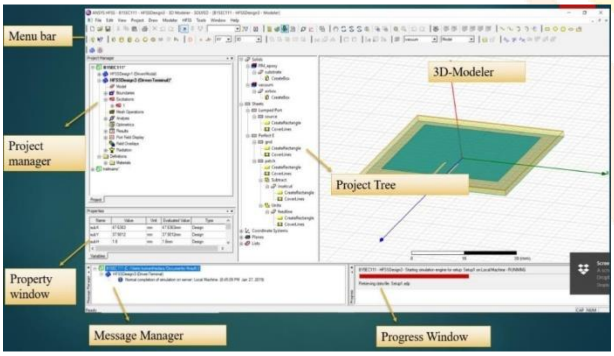


HFSSWINDOWS

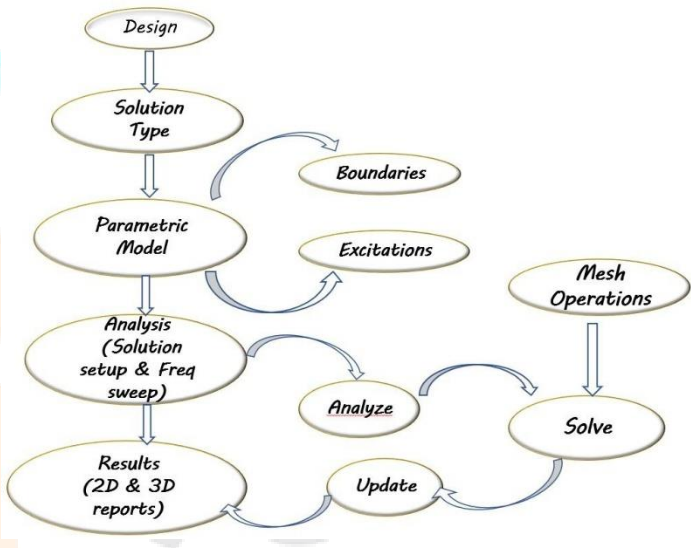
Toopenanew3DModelerwindow, done ofthe following:

1.Insert a new HFSS design into the current project.

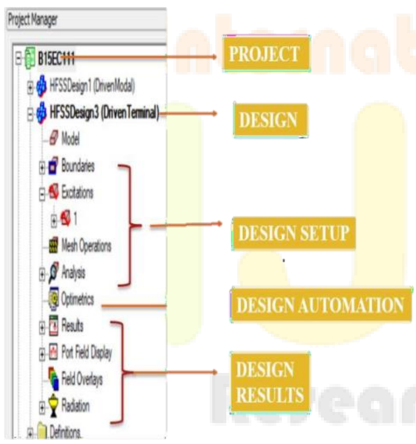
2.Double-click an HFSS design in the project tree.

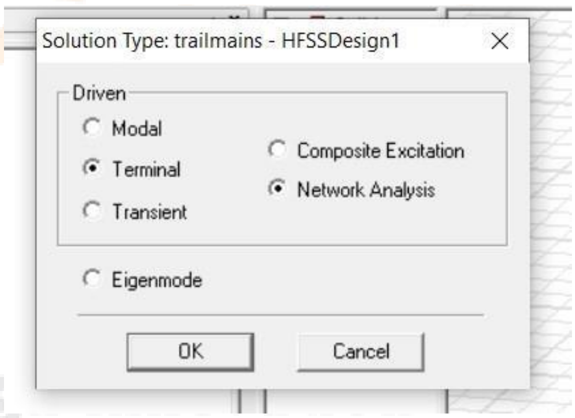


DESIGNFLOW



SETSOLUTIONTYPE

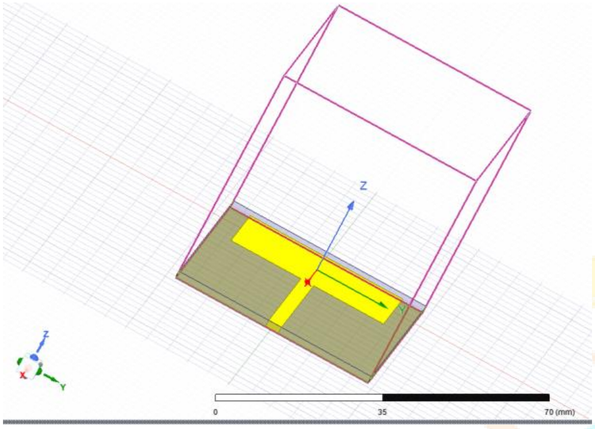




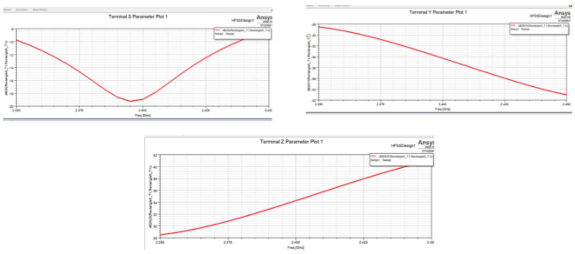
RESULTS:

Designing of Rectangular patch antenna.

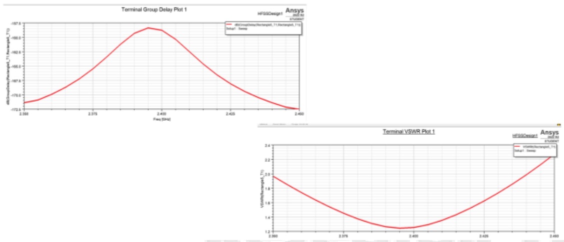
To determine the terminal-based S parameters of single- and multi-conductor transmission line ports, select the Driven Terminal solution type. The voltages and currents present on the terminals will be used to represent the S-matrix solutions. By default, network analysis is used.



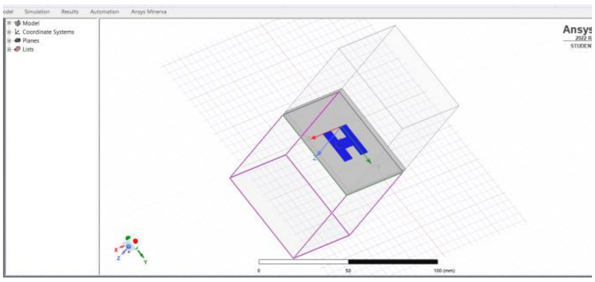
Parameters

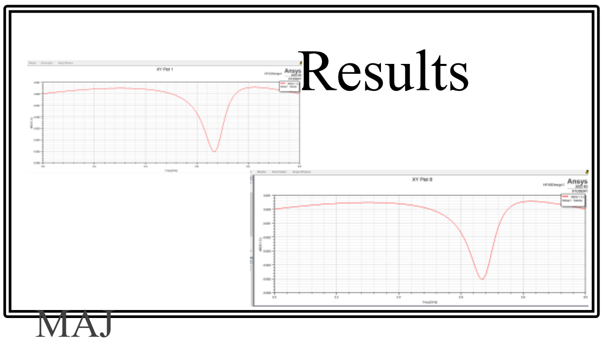


Group Delay and VSWR Ratio



Designing of H Slot Patch Antenna





MAJ
OR
PROJ
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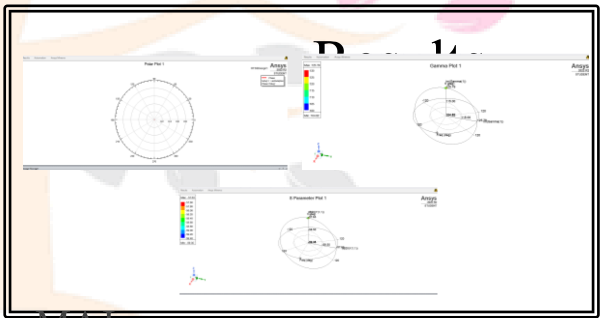
BATC
H-15



MAJ
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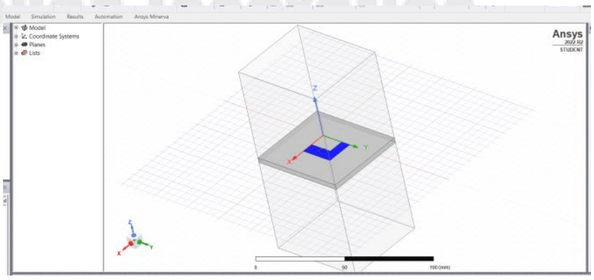
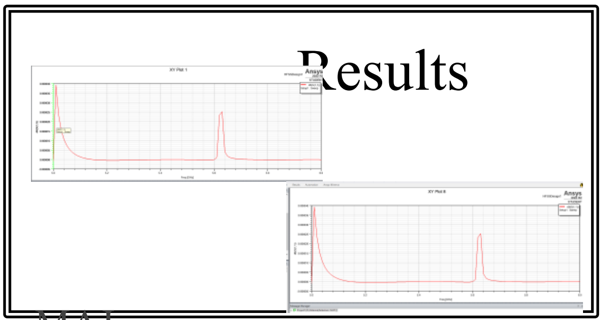
Designing of L Slot Patch Antenna





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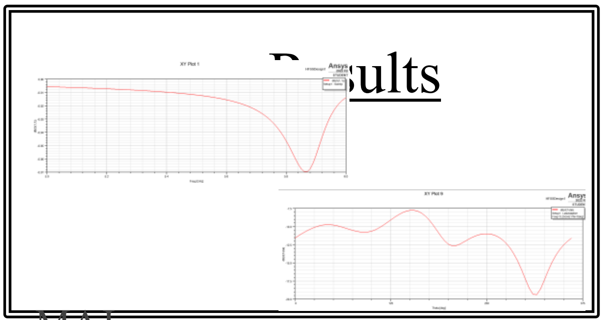

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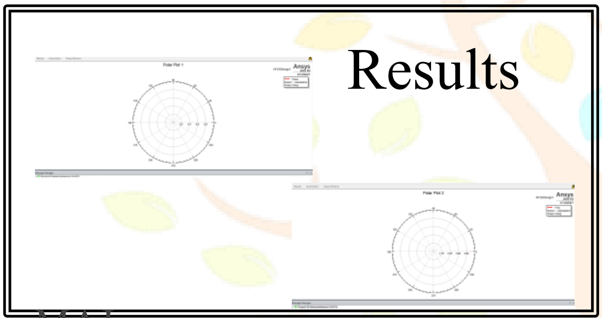

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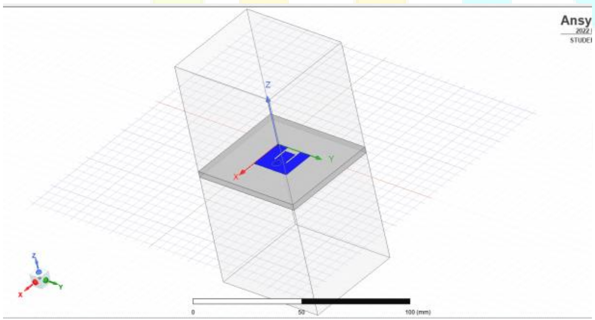
Designing of E Shaped Patch Antenna



NEED FOR SOURCE AND AIRBOX
AIRBOX

1.Airbox is required for HFSS to mimic free space radiation. Infinite free space is reduced to a small computation domain and employed as a radiation barrier.

2.This minimize reflections from outer surfaces and ensures maximum absorption.

3.To achieve this, the distance from the radiator must be at least /4 (or /2) for surfaces with significant radiating properties. The wavelength for theThe symbol here represents the lowest frequency. Because identical impedance mismatches can cancel at quarter wavelengths, a distance of /4 from the radiating surface is chosen. By preventing reflected waves, this assures that the radiation barrier absorbs all of the radiation.

4.Maximumabsorptionofenergyoccurswhenthefields areperpendiculartotheboundary.

Fig.15. SourceandAirboxRepresentationin3Dmodel

Source is created in order to transfer the RF powerfrom ground plane to patch.

The electric field is assumed to be normal to these surfaces..

ANALYSIS SET UP

Solution Frequency - Define the frequency and units at which to create the solution for each Driven solution arrangement. Define a frequency sweep to solve over a range of frequencies.

The maximum number of mesh refinement cycles that you would want HFSS to carry out is known as the Maximum Number of Passes. The adaptive analysis comes to an end if this values reached; otherwise, it continues until the maximum number of passes have been made.

VALIDATION AND SIMULATION CHECK

Analysis on a model. When you Project Validation: It is crucial to carry out a project validation check before you execute an conduct a validation check on a project, HFSS examines every setup element to ensure that all essential steps have been taken and that the settings are appropriate. To perform a validation, check on the active project:

1.On the HFSS menu, click Validation Check

HFSS checks the project set up, and then the Validation Check window appears.

2.View the results of the evalidation check in the Validation Check window.

Using the Message Manager - The Message Manager shows messages connected to the development of a project, such as warning messages concerning the configuration of the design or informational messages about the status of an analysis.

To display or hide the Progress window, do one of the following:

1)On the View menu, click Progress Window.

2)A check box appears next to this command if the Progress window is visible.

3)Right-click the history tree, and then click Progress on the short cut menu.

4)A check box appears next to this command if the Progress window is visible.

III. CONCLUSION

It is done to simulate a microstrip patch antenna. The several methodologies required for simulation are completed. The patches and substrate are made. There are observed radiation patterns. The 2.4 GHz and 5 GHz rectangular patch antenna was created using Ansoft HFSS. The antenna's design makes it appropriate for Wi-Fi applications, cell phone antennas, and mobile communication

Researchers have looked into two characteristics of microstrip antennas. The design of a standard rectangular microstrip antenna with a patch size of 38.03*28.30 is the first aspect, and a proposed microstrip antenna with a smaller patch size is the second. The primary focus is on researching how the microstrip antenna may reduce return loss. High-performance computing has been used to develop and simulate a rectangular microstrip antenna and the suggested microstrip antenna model.

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