Design & Analysis of 1x4 Microstrip Patch Antenna for 2.4GHz Application

B.E. Dissertation

Submitted in partial fulfillment of the requirement of

University of Mumbai

For the Degree of

Bachelor of Engineering

(Electronics & Telecommunication Engineering)

by

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"Design & Analysis of 1x4 Microstrip Patch Antenna for 2.4GHz Application"

is a bonafide work done by

Shaikh Musheer Ahmed (16DET126)

and is submitted in the partial fulfillment of the requirement for the degree of

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to the

University of Mumbai

Supervisor **Examiner**

Head of Department **Director**

Certificate of Approval by Examiners

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Declaration

I declare that this written submission represents ours ideas in ours own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in ours submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Acknowledgement

We are highly grateful to the **PROF. AFZAL SHAIKH, HOD of Electronics & Telecommunication Department, Kalsekar Technical Campus (New Panvel)**, for providing this opportunity to carry out the project. We would like to express our gratitude to other faculty members of Electronics & Telecommunication Engineering Department for providing academic inputs, guidance and encouragement throughout this period. We would like to express our deep sense of gratitude and thank to **ASST. PROF. Mazhar Malagi**, for the wise council and able guidance it would have not been possible to carry out this project in this manner. Finally, we express our indebtedness to all who have directly or indirectly contributed to the successful completion of this project.

Shaikh Musheer Ahmed (16DET126) ______________

Contents

Chapter 1

Introduction

1.1 Abstract

Microstrip patch antennas are the most useful antennas for the present trend of applications in communications. The well known advantageous mechanical characteristics (low profile, light weight, planar but conformal to non-planar structures, easy to fabricate), flexibility in terms of electromagnetic parameters (radiation pattern, gain, impedance, polarization) and low cost are the key features of the success of such antennas. To meet the requirements of aircraft, spacecraft, satellite and missile applications where size, weight, cost, performance, ease of installation, low profile and easy integration to circuits, high efficiency antennas are required. Microstrip antenna arrays are most suitable for such applications. In this paper circular patch antenna arrays are designed for the application of RADAR at 2.4GHz. Single patch antenna is designed using probe feeding technique. Arrays of 1X4 are designed using edge feeding technique. The antenna arrays are designed and simulated on FR4 substrate and excited using probe and edge feeding techniques. The antenna arrays are simulated using the High Frequency Structure Simulator (HFSS) software version v17.2 and the parameters like gain, return loss, radiation pattern and VSWR are evaluated at that frequency.

KEYWORDS: Microstrip Patch Antenna, FR-4 Substrate, Edge feed and probe feed technique.

1.2 Acknowledgement

I extremely fortunate to be involved in an exciting and challenging project like " Design & Analysis of 1x4 Microstrip Patch Antenna for 2.4GHz Application" It has enriched our life, giving us an opportunity to work in field of RF Domain and Antenna Fabrication. This project increased our thinking and understanding capability and after the completion of this project, we experience the feeling of achievement and satisfaction. We would like to express our greatest gratitude and respect to our guide Prof. Mazhar Malagi for his excellent guidance, valuable suggestion and endless support. He has not only been wonderful guide but also a genuine person. We consider ourselves extremely lucky to be able to work under guidance of such a dynamic personality. Also we would like to thanks our HOD Prof. SHAIKH AFZAL For guiding us with the designing and helping us to improve our project. Actually, he is one such genuine person for whom our words will not be enough to express. It was impossible for us to complete our project without their help. We are also grateful to our Director Mr. ABDUL RAZZAK HONNUTAGI for their encouragement. We like to express our grateful thanks to our classmates, all staffs and faculty members of electronics and telecommunication engineering department who willingly rendered us their unselfish help and support Last but not least, we want to convey our heartiest thanks to our parents for their immeasurable love, support and encouragement.

1.3 Background Information

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.

The electromagnetic spectrum is regarded as a reference tool for communication as it involves the use of the non-visible region of the electromagnetic spectrum used for communication through the use of radio (Radio waves). This leads to an increasing use of the capabilities of the Electromagnetic Spectrum leading to the advent of different avenues where it can be utilized in area's such as; automotive communications, smart antennas, indoor communications, sensors etc.

Antennas, traditionally the last part of a conventional front end and completely separated from the circuit part, have been transformed to a variety of low profile and low weight structures following developments in planar Microstrip antennas (James and Hall 1989). The demand of wireless technologies is increasing rapidly day by day, with time and requirements. These devices are increasingly getting smaller in size and hence the antennas required for transmit and receive signals also have to be smaller and lightweight. This leads to a process where small size, light weight, case of installation are regarded as advantages in relation to the construction of a low profile Microstrip antenna. This leads to an increasing demand for the compactness property of the Microstrip antenna leading to the initiation of the integration of circuits and antennas on the same substrate resulting in antenna-circuit modules, which can also be met under the term active integrated antennas (Lin and Itoh 1994). Due to the lightweight, telecommunication systems can be structured to be mounted when required or necessary. Moreover, they are easily fabricated, due to low cost and are easy integrated into arrays or into microwave printed circuits.

1.4 Aim and Objectives

Microstrip patch antenna are used to send on-board parameters of article to the ground while under operating conditions. The aim and objective of the thesis is to design and fabricate a probe-fed Circular Microstrip Patch Antenna and study the effect of antenna dimensions Length (L), substrate parameters relative Dielectric constant (Er), and substrate thickness (h) on the Radiation parameters, the Return loss and the Voltage standing wave ratio.

1.5 What is an Antenna?

An antenna is a device (usually metallic) for sending or receiving electromagnetic waves. The antenna is an important part of radio equipment. The antenna has to be tuned to the right frequency or the radio waves can neither be emitted nor captured efficiently. In transmission, a radio transmitter applies a radio frequency to the terminals of the antenna and then the antenna radiates the energy from the antenna as electromagnetic waves. In reception, an antenna intercepts some of the power of an electromagnetic wave to produce a radio frequency at its terminals that is applied to a receiver in order to be amplified and demodulated. In some cases the same antenna can be used for both transmitting and receiving.

1.6 Antenna parameters

The major parameters of an antenna are defined in the following subsection.

Antenna Gain

Antenna gain is defined as the radio between the radiation intensity in a given particular direction and total input power. The radiation intensity Unexpressed the power radiated per solid angle. IN terms of U the Antenna gain in a specified direction can be calculated.

$$G = \frac{U}{Pin/4\pi}$$

Antenna Efficiency

Antenna efficiency is defined by IEEE Std 145-1993 "Standard Definition of Terms for Antennas "as "The ratio of the total power radiated by an antenna to the net power accepted by the antenna from the connected transmitter". It is sometimes expressed as percentage (less than 100), and it is frequency dependent.

Antenna Effective Area

In electromagnetic and antenna theory. Antenna aperture of effective area is a measure of how effective an antenna is at receiving the power of radio waves. The aperture is defined as the area, oriented perpendicular to the direction of an incoming wave, which, would intercept the same amount of power from that waves as is produced by the antenna receiving it. At any point, a beam of radio waves has an irradiance or power flux density (PFD) which is the amount of radio power passing through a unit area.

Directivity

In electromagnetics, directivity is a figure of merit for an antenna. It measures the power density the antenna radiates in the direction of its strongest emission, versus the power density radiated by an ideal isotropic radiator (which emits uniformly in all directions) radiating the same total power.

An antenna's directivity is a component of its gain; the other component is its (electrical) efficiency. Directivity is an important measure because most emissions are intended to go in a particular direction or at least in a particular plane (horizontal or vertical); emissions in other directions or planes are wasteful (or worse).

Bandwidth

The properties of input impedance, polarization gain of an antenna do not necessary vary in the same manner, moreover there is no distinctive character of the bandwidth to calculate percentage of bandwidth: per of BW = (f2-f1)/f0*100per

Radiation Pattern

A radiation pattern defined as the variation of the power radiation from an antenna which is away from the antenna. The radiation pattern is a plot of the fare –field radiation properties of an antenna. The spatial coordinates which are specified by the elevation angle () and the azimuth angle (). It is a plot of the power radiated from an antenna per unit solid angle which is nothing but the radiation intensity. It can plotted as a 3D graph. It is an extremely important parameter as is show the antenna directivity as well as gain at various points in space.

Return Loss

In telecommunications, 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 and Pr is the reflected power. Return loss is related to both standing wave ratio (SWR) and reflection coefficient (). Increasing return loss corresponds to lower SWR. Return loss is a measure of how well devices or lines are matched. A match is good if the return loss is high. A high return loss is desirable and results in a lower insertion loss.

Beam Width

In an antenna pattern the half power beam width is the angle between the half power (-3dB) points of the main lobe, when referenced to the peak effective radiated power of the main lobe.

Input Impedance

The input impedance of an electrical network is the impedance from the source into the network being connected. In other words, the input impedance is the impedance, if placed across the input terminals that would produce the same voltage across and current through the input terminals as the electrical network being connected. Therefore, the input impedance of the network being connected and the output impedance of the source determines the transfer function from the source to the input terminals of the circuit.

1.7 Voltage Standing Wave Ratio (VSWR)

For a radio (transmitter or receiver) to deliver power to an antenna, the impedance of the radio and transmission line must be well matched to the antenna's impedance. The parameter VSWR is a measure that numerically describes how well the antenna is impedance matched to the radio or transmission line it is connected to.

1.8 Overview of Microstrip Antenna

The Microstrip antenna is made up of a conducting patch on a ground plane separated by the dielectric substrate. This concept was undeveloped until the revolution in large-scale integration of electronic circuit in 1970.

This led to the early work by Munson on Microstrip antennas for use as a low profile flush mounted antennas on rockets and missiles showed that this was a practical concept for use to solve many antenna system problems. This provided a platform for various mathematical models to be developed for this antenna and its applications were also extended to many other fields. This is represented through the number of journals and articles over the last ten years. The Micros trip antennas are regarded as the present day antennas designers' choice; this is due to the fact that Low dielectric constant substrates are preferably used for maximum radiation, the conducting patch can take any shape but rectangular and circular configurations are the most are the most widely used configuration. A Microstrip antenna is characterized by its length, width, input impedance and gain and radiation patterns. These various parameters of the Microstrip antenna are discussed in subsequent chapters.

Note: The length of the antenna is nearly half wavelength in the dielectric (this governs the resonant frequency of the antenna).

1.9 What is Array Antenna?

An antenna array (often called a 'phased array') is a set of 2 or more antennas. The signals from the antennas are combined or processed in order to achieve improved performance over that of a single antenna.

An antenna array is a set of individual antennas used for transmitting and/or receiving radio waves, connected together in such a way that their individual currents are in a specified amplitude and phase relationship. This allows the array to act as a single antenna, generally with improved directional characteristics (thus higher antenna gain) than would be obtained from the individual elements. The resulting array in fact is often referred to and treated as "an antenna," particularly when the elements are in rigid arrangement with respect to each other, and when the ratio of currents (and their phase relationships) are fixed. On the other hand, a steerable array may be fixed physically but has electronic control over the relationship between those currents, allowing for adjustment of the antenna's directionality without requiring physical motion.

The array uses electromagnetic wave interference to enhance the radiative signal in one desired direction at the expense of other directions. It may also be used to null the radiation pattern in one particular direction, especially for a receiving antenna in the face of a particular interfering source.

1.10 Why Micro strip Patch Antennas is been used?

An antenna array (often called a 'phased array') is a set of 2 or more antennas. The signals from the antennas are combined or processed in order to achieve improved performance over that of a single antenna. The antenna array can be used to:

- increase the overall gain
- provide diversity reception
- cancel out interference from a particular set of directions
- "steer" the array so that it is most sensitive in a particular direction
- determine the direction of arrival of the incoming signals
- to maximize the Signal to Interference Plus Noise Ratio (SINR)

Chapter 2

Literature Review

2.1 Introduction

The Microstrip Patch Antenna consist of a single-layer design which includes four parts (Patch, ground plane, substrate, and the feeding part). These antennas are integrated with printed strip-line feed networks and active devices. This is a relatively new area of antenna engineering. Patch antennas are classified as single - element resonant antennas. Once the frequency is obtained, everything (such as radiation pattern input impedance, etc.) remains constant. The patch is a very slim, radiating metal strip (or array of strips) located on one side of a thin no conducting substrate, the ground plane is the same metal located on the other side of the substrate. The patch is usually made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. The substrate layer thickness is 0.01 – 0.05 of free-space wavelength. This is used primarily to provide proper spacing and mechanical support between the patch and its ground plane. It is also often used with high dielectric-constant material to load the patch and reduce its size.

Microstrip patch antennas consist of a very high antenna quality factor (Q). It shows the losses associated with the antenna where a large Q leads to narrow bandwidth and low efficiency. Q can be reduced by increasing the thickness of the dielectric substrate. But as the thickness increases, an increasing fraction of the total power delivered by the source goes into a surface wave.

2.2 Types of Patch Antenna

There are numerous shapes of Microstrip patch antennas; they have been designed to match specific characteristics.

In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, and elliptical or some other common shape as shown in Fig 1. For a circular patch, the radius of the patch is usually 17mm, where to is the free-space wavelength. The patch is selected to be very thin such that t (where t is the patch thickness). The Feed location is usually (5.5,0). The dielectric constant of the substrate is Er-4.4

2.3 Common Shapes of Patch Antennas

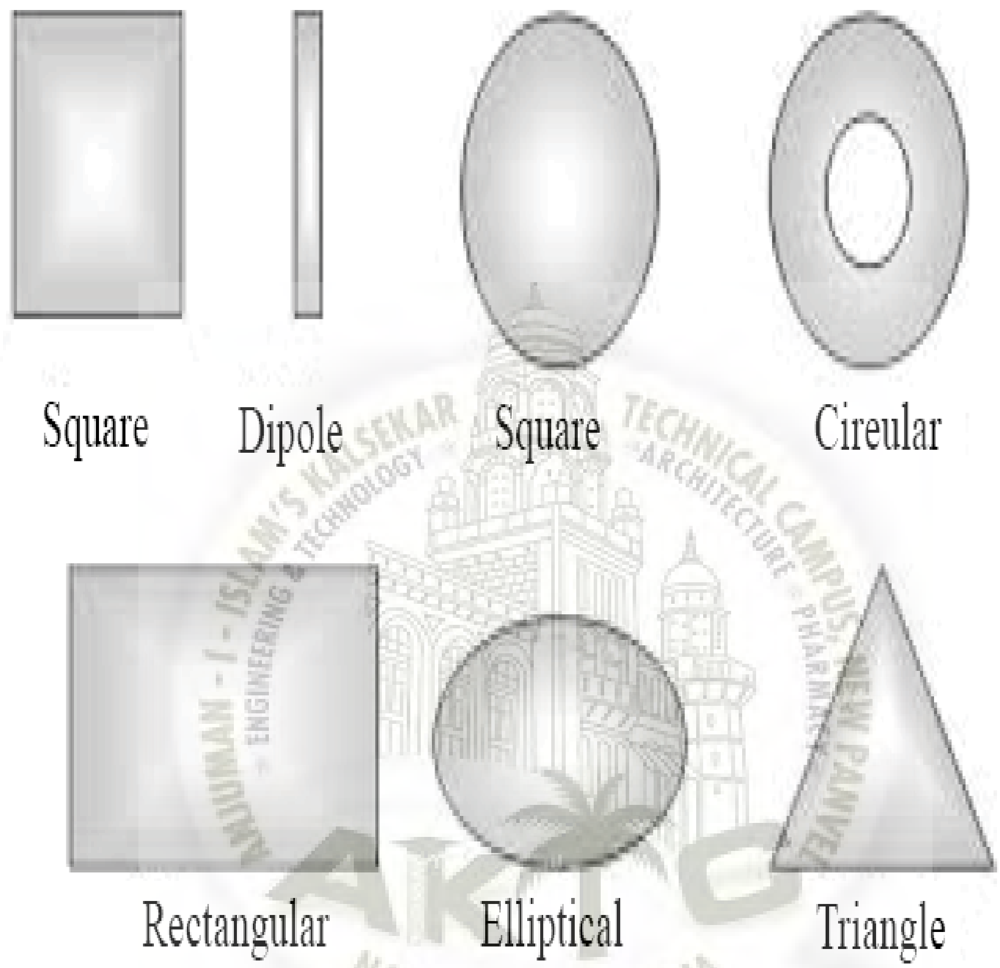


Figure 1 Different shapes of patch.

Microstrip patch antennas radiate mainly due to the fringing fields between the patch edge and the ground plane.

The selecting of a substrate is very important, considerations are made depending on the temperature, humanity, and other environmental ranges of operating. The Thickness of the substrate h has a big effect on the resonant frequency and bandwidth of the antenna. The bandwidth of the Microstrip antenna will increase with an increase in substrate thickness h but with limits, otherwise the antenna will stop resonating.

2.4 Feeding Techniques

Microstrip patch antennas can be fed using different methods. These methods are classified into two categories;

- Contacting and
- Non-contacting.

The contacting method involves the process where the RF power is fed directly to the radiating patch using a connecting element such as a MicroStrip line. In the non-contacting method, this consist of an electromagnetic field coupling done to transfer power between the Microstrip line and the radiating patch.

There are many methods of feeding a Microstrip antenna. Although, the popular four method includes:

- a.Microstrip Line
- b.Coaxial Probe (Coplanar feed)
- c.Proximity Coupling
- d.Aperture 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.

2.4.1 Microstrip Line:

This is the widely used method of feeding because it is very simple to design and analyse, and very easy to manufacture. This involves a conducting strip connected directly to the edge of the Microstrip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage where the feed is etched on the same substrate to provide a planar structure. However, an increase in the thickness of the dielectric substrate used leads to an increase in the surface waves and spurious feed radiation, which hampers the bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation.

The impedance of the patch is given by:

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

The characteristic impedance of the transition section should be:

$$Z_T = \sqrt{50 + Z_{\alpha}}$$

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 Microstrip 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 strip can be found using:

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

The length of the transition line is quarter the wavelength.

Therefore:

$$l = \frac{\lambda}{4} = \frac{\lambda_0}{4\sqrt{\varepsilon_{reff}}}$$

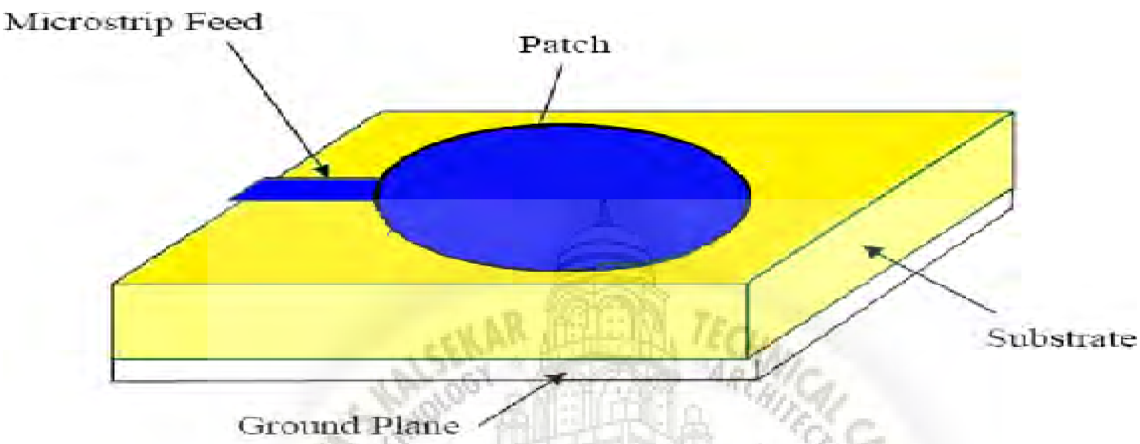


Fig 2a: Microstrip line feed Technique

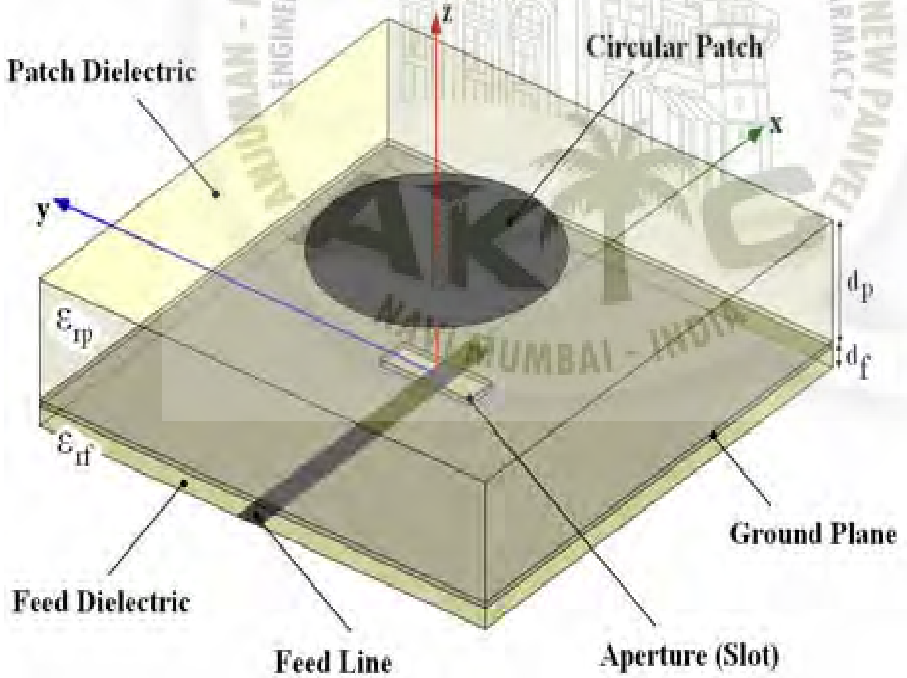


Fig 2b: Circular patch Microstrip Antenna with the line feed

2.4.2 Coaxial Probe (Coplanar Feed):

The Coaxial probe or feed is a very common technique used for feeding Microstrip patch antennas. The coupling of power to the patch antenna through a probe is very simple, cheap, and effective way. If the feed point is adjusted to 50, the use a 50 coaxial cable with N-type coaxial connector. The N-coaxial connector is coupled to the ground plane of the Microstrip

antenna and the center connector of the coaxial will be passed through the substrate and soldered to the patch. The advantage of this feeding scheme is the feed can be placed at any

desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation. However, the main disadvantage is that it provides narrow bandwidth and the modelling is difficult, since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, making it not completely planar for thick substrates (h=0.02).

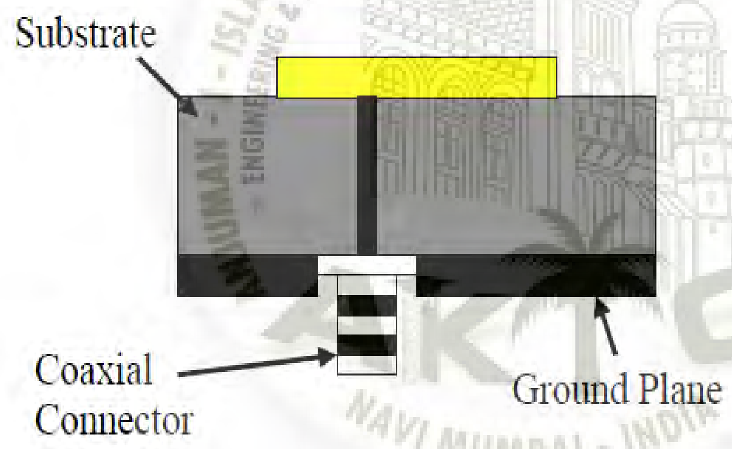


Fig 2.3: Coaxial Probe feed Technique

2.4.3 Proximity Coupling:

This type of feed technique is known as the electromagnetic coupling scheme. This involves the use of two substrate Er1 and Er2 consisting of the patch at the top, and the ground plane in the bottom. A Microstrip line is connected to the power source and lying between the two substrates.

The principle involves the capacitive behavior between the patch and the feed strip line.

Analysis and design of such an antenna complicated than the other ones discussed in the previous sections because it takes into account the effect of the coupling capacitor between the strip feed line and the patch as well as the equivalent R-L-C resonant circuit representing the patch and the calculating of two substrates (Er1 and Er2).

The advantage of this feed technique is the elimination of spurious feed radiation and provision of very high bandwidth (as high as 13per), due to overall increase in the thickness of the Microstrip patch antenna.

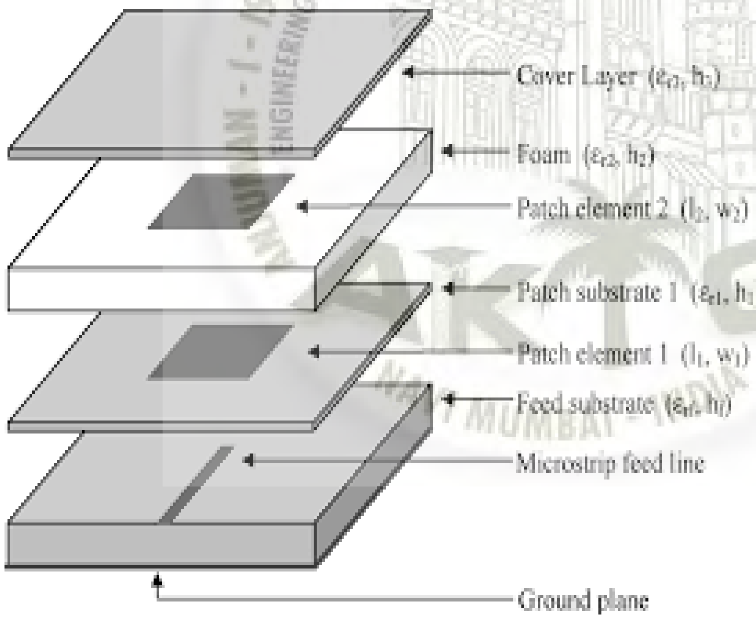


Fig 2.4: Proximity Coupling feed Technique

2.4.4 Aperture Coupling:

This technique involves the use of the aperture mechanism, where the radiating patch and the Microstrip feed line are separated by the ground plane.

The ground plane consist of an aperture usually centered under the patch, in the shape of a circle or rectangular, and separates two substrates: the upper substrate Er1 with the patch on it, and the lower substrate Er2 with the Microstrip feed line under it, spurious radiation is minimized.

This involves the use of a high dielectric material as the bottom substrate and a thick, low dielectric constant material is used as the top substrate to optimize radiation from the patch. This type of coupling gives wider bandwidth.

The disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which leads to an increase in the antenna thickness.

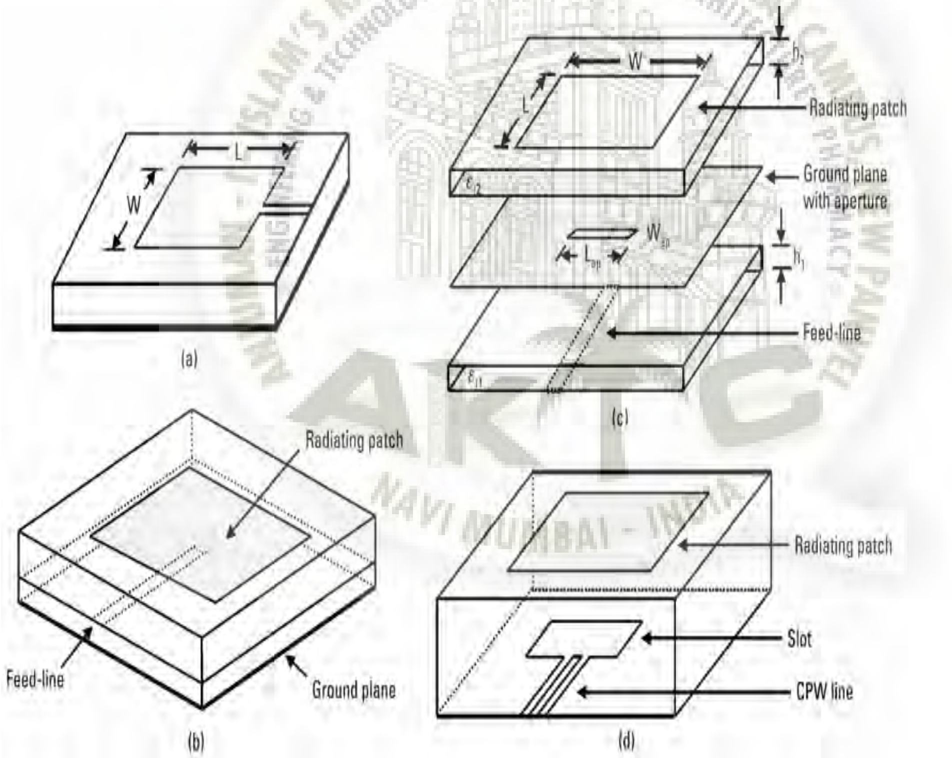


Fig 2.5: Aperture coupling feed Technique

Chapter 3

METHODOLOGY

3.1 Introduction to HFSS

HFSS is a commercial finite element method solver for electromagnetic structures from Ansys. The acronym originally stood for high frequency structural simulator. It is one of several commercial tools used for antenna design, and the design of complex RF electronic circuit elements including filters, transmission lines, and packaging. It was originally developed by Professor Zoltan Cendes and his students at Carnegie Mellon University. Prof. Cendes and his brother Nicholas Csendes founded Ansoft and sold HFSS stand-alone under a 1989 marketing relationship with Hewlett-Packard, and bundled into Ansoft products. [1] After various business relationships over the period 1996-2006, H-P (which became Agilent EEs of EDA division) and Ansoft went their separate ways: [2] Agilent with the critically acclaimed [3] FEM Element and Ansoft with their HFSS products, respectively. Ansoft was later acquired by Ansys.

The Ansoft High Frequency Structure Simulator (HFSS) is a full-wave electromagnetic (EM) software package for calculating the electromagnetic behavior of a 3-D structure.

Using HFSS, you can compute:

Basic electromagnetic field quantities and, for open boundary problems, radiated near and far fields; The eigen modes, or resonances, of a structure; Port characteristic impedances and propagation constants; Generalized S-parameters and S-parameters renormalized to specific port impedance.

3.2 Features of HFSS:

Capabilities:

- Accurate full-wave EM simulation
- Import/export of 3D structures
- Automatic adaptive mesh generation and refinement
- Adaptive Lanczos-Padé Sweep for fast frequency sweeps
- Inclusion of skin effect, losses
- Direct and iterative matrix solvers

Solution Data (Visualization):

- S-, Y-, Z-parameter matrix (2D plot, Smith Chart)
- vPort characteristic impedance
- Current, E-field, H-field (3D static and animated field
- plot in vector display or magnitude display)
- Far-field calculation (2D, 3D, gain, radiation pattern)
- Material losses, radiation losses.

3.3 Ansoft terminology

The Ansoft HFSS window has several optional panels

- A. Project Manager
- B. Message Manager
- C. Property window
- D. Progress window
- E. 3D Modeler window

These above managers and windows are shown in fig. and their details are given in coming sections

3.4 HFSS window

- From Windows Start menu, open the Control Panel
- Select System.
- From the left pane, select Advanced system settings
- Click Environment Variables
- Under User variables, click New
- Set the variable LM-LICENSE-FILE and click OK.
- When the initial setup is complete, start the tool.

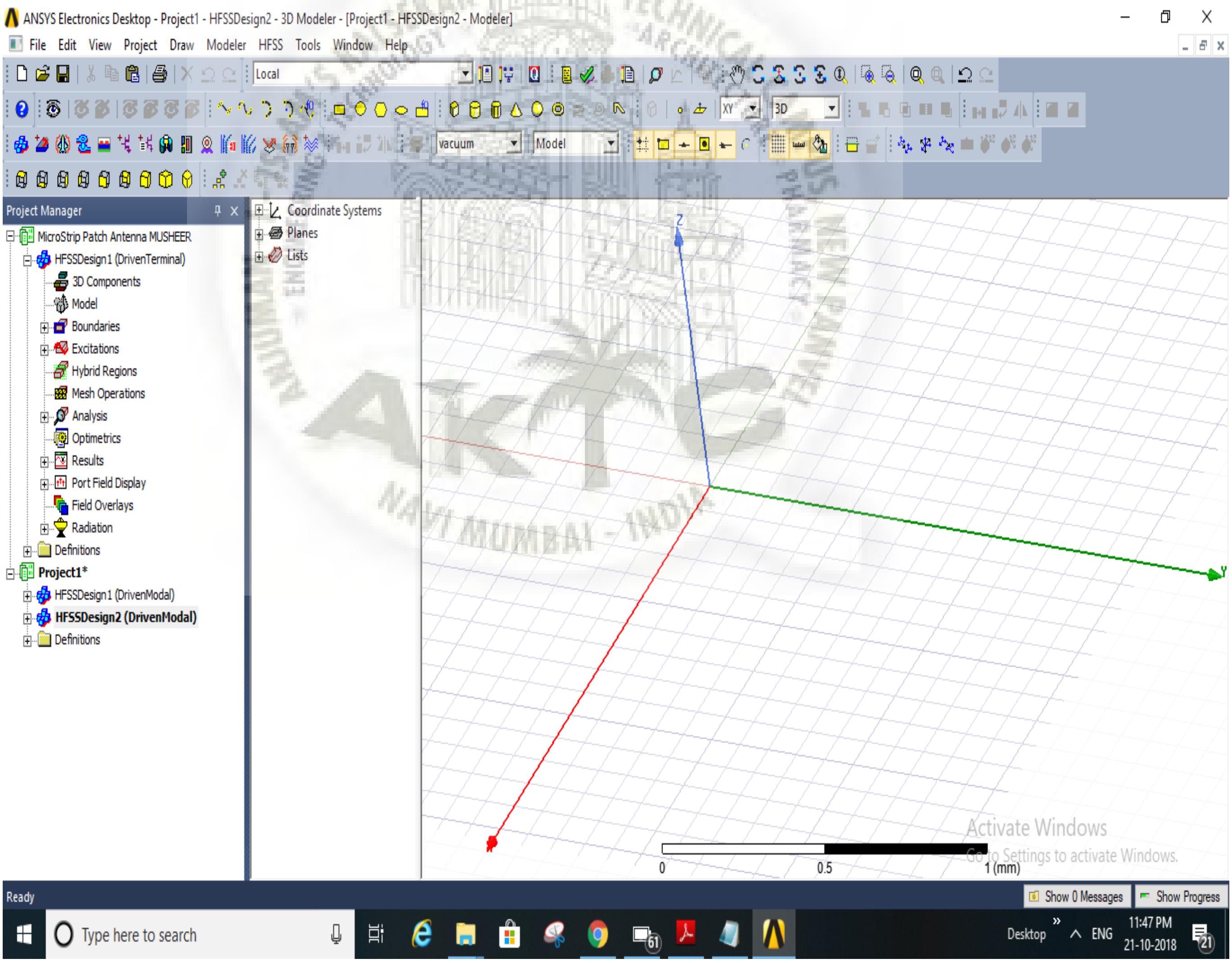


Figure 3.1 Ansoft HFSS window

3.5 Project Mangers

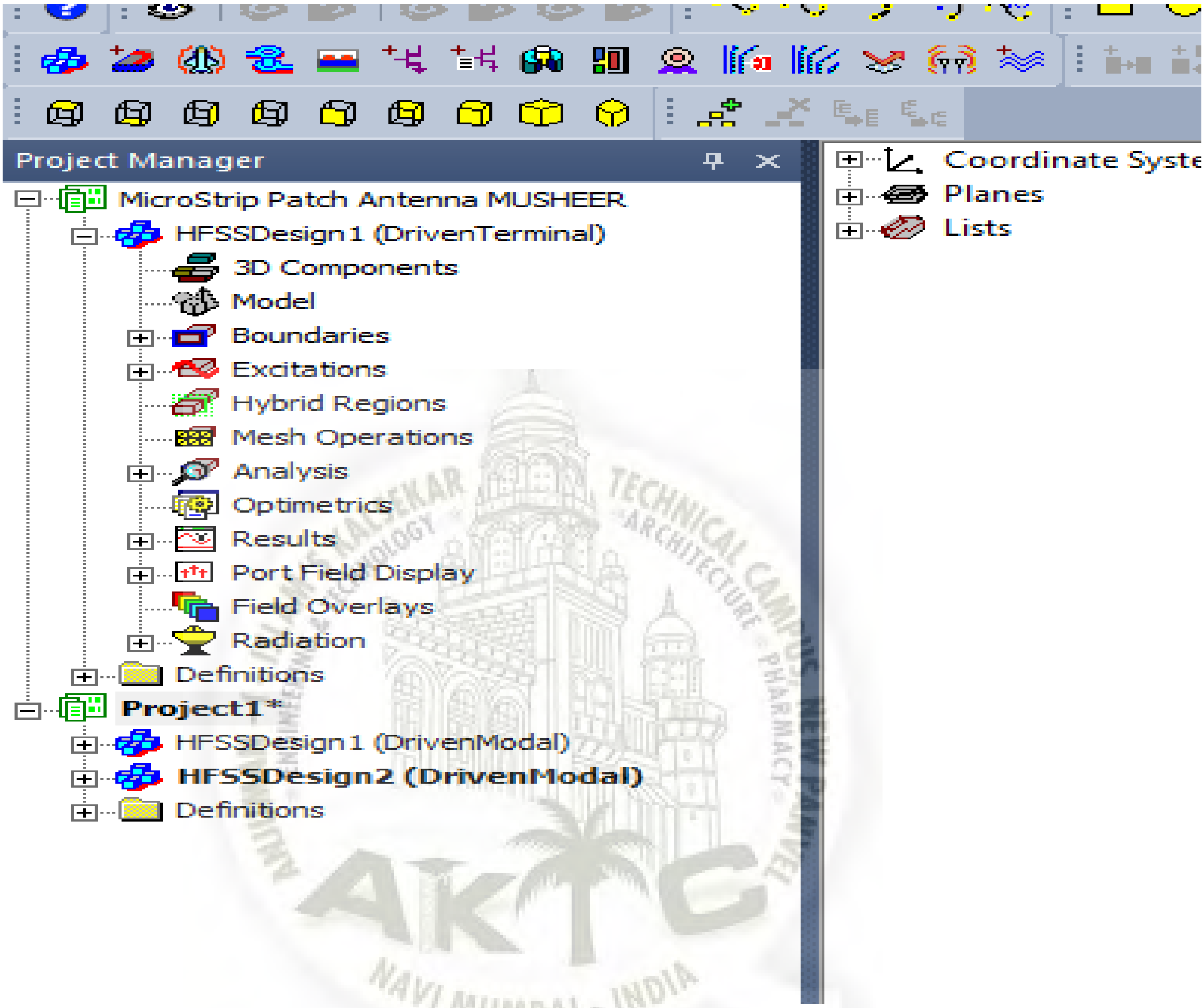


Figure 3.2: Ansoft project manager

3.6 Modeler window

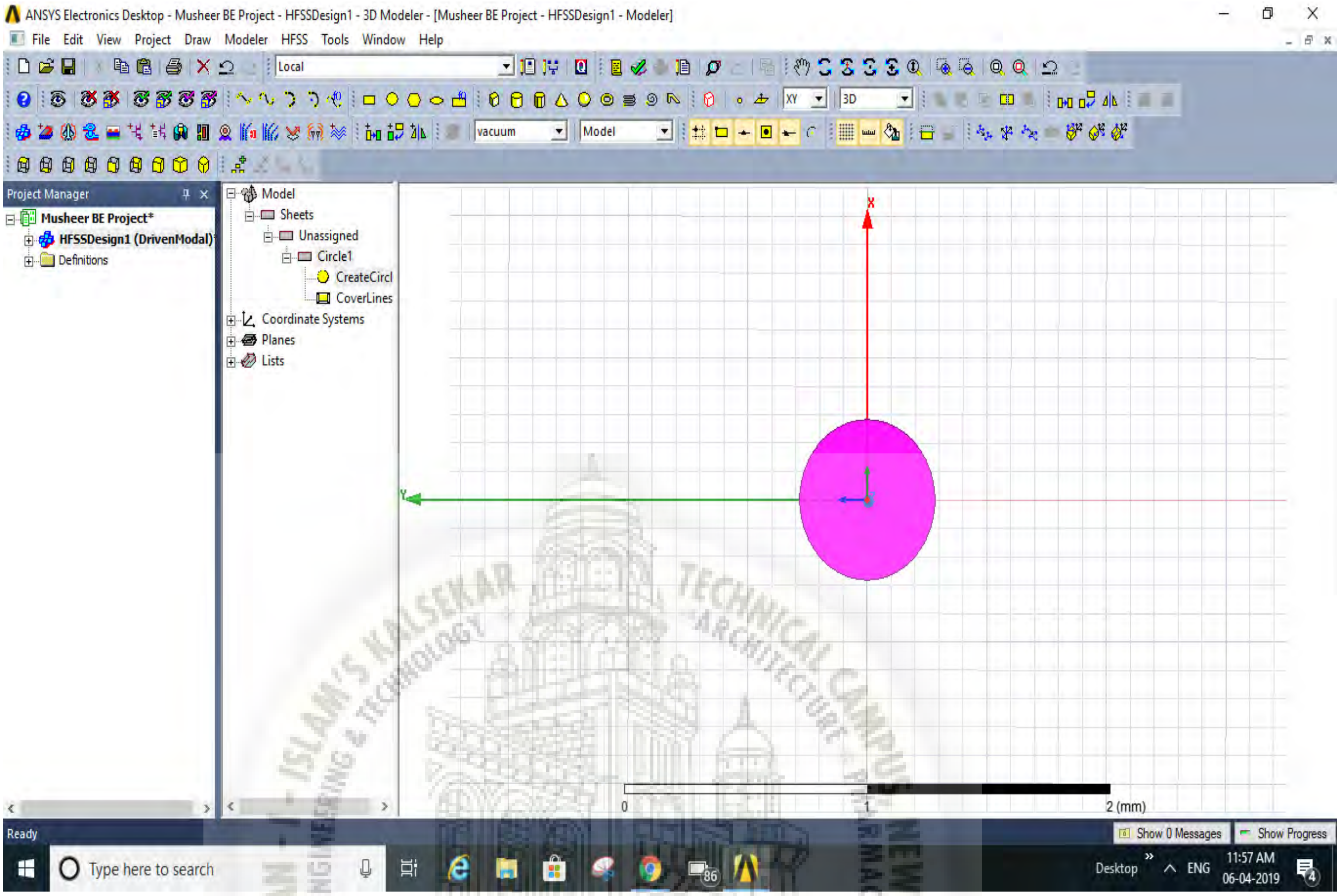
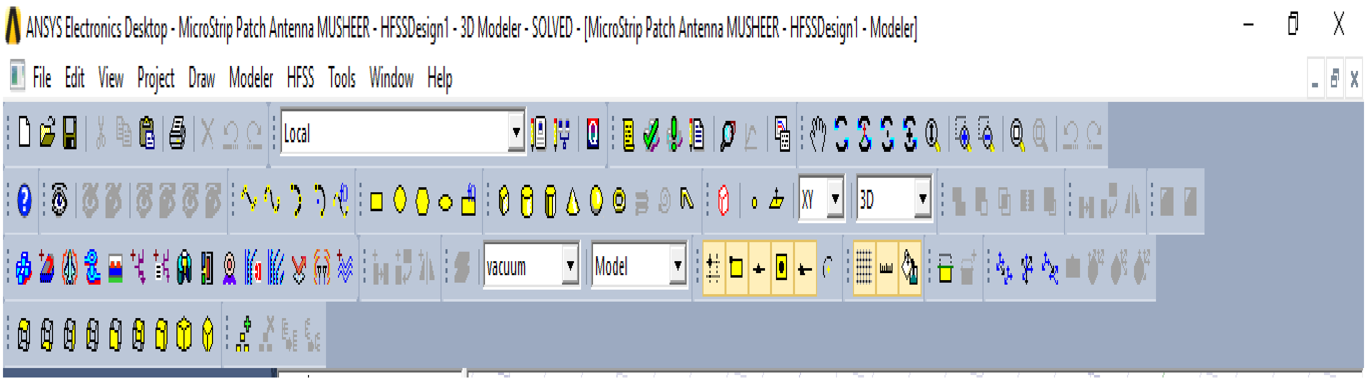


Figure 3.3: Modeler window

3.7 Toolbars:

The toolbar buttons are shortcuts for frequently used commands. Toolbars are displayed in this illustration of the Ansoft HFSS initial screen, but your Ansoft HFSS window probably will not be arranged this way.



3.8 Ansoft HFSS Desktop

Ansoft HFSS Desktop provides an intuitive, easy-to-use interface for developing RF device models. Creating designs, involves the following.

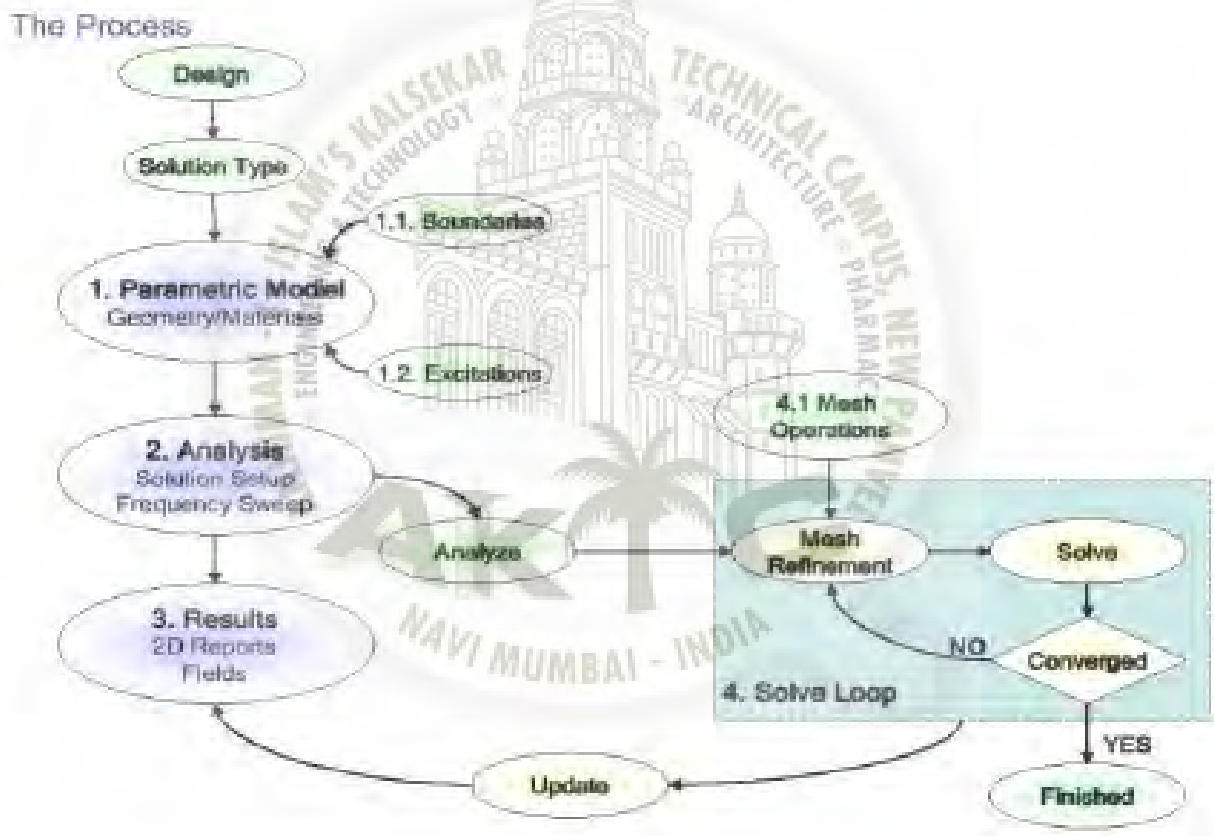
A. Parametric Model Generation -creating the geometry, boundaries and excitations.

B. Analysis Setup -defining solution setup and frequency sweeps.

C. Results -creating 2D reports and field plots.

D. Solve Loop -the solution process is fully automated.

To understand how these process co-exist, determine the illustration shown here,



Flow chart illustration of Ansoft HFSS

3.9 Opening an HFSS project

This section describes how to open a new or existing project. First, go the HFSS software and click to open. Then go file and click Open file. And select desired file and open it.

3.10 Opening a New project

a. In an Ansoft HFSS window, select the menu item File. New.

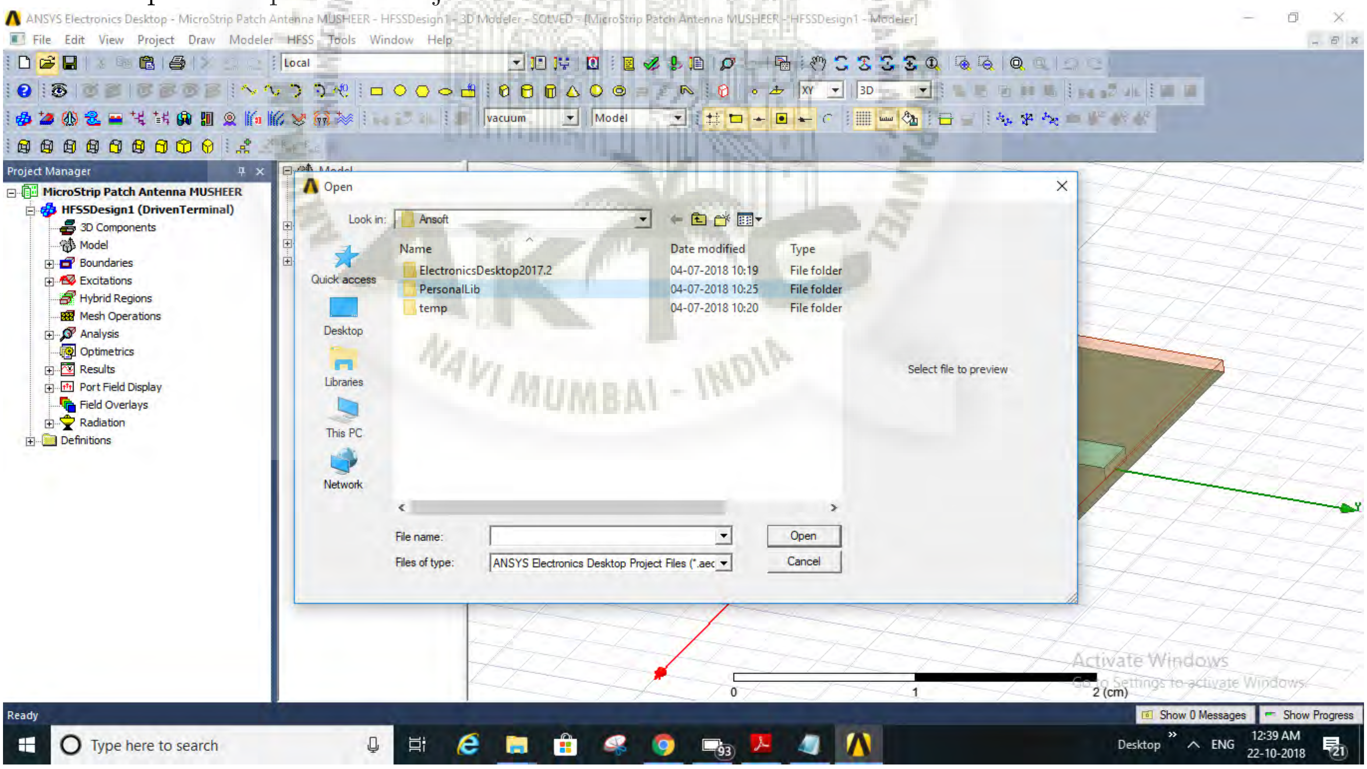
b. Select the menu Project. Insert HFSS Design.

3.11 Opening an Existing HFSS project

To open an existing project:

a. In an Ansoft HFSS window, select the menu File ¿ Open. Use, the Open dialog to select the project.

b. Click Open to Open the Project.



3.12 To set the solution type

Select the menu item HFSS - Solution Type

3.13 Solution Type Window

Choose one of the following:

- Driven Modal
- Driven Terminal
- Driven Transient
- Eigen Mode

3.14 Getting Help

If you have any questions while you are using Ansoft HFSS you can find answers in several ways:

3.15 Ansoft HFSS Online Help

Provides assistance while you are working.

- To get help about a specific, active dialog box, click the Help button in the dialog box or press the F1 key.
- Select the menu item Help ¿ Contents to access to online help system.
- Tooltips are available to provide information about the tools on the toolbars or dialog boxes. When you hold the pointer over a tool for a brief time, a tooltip appears to display the name of the tool.
- As you move the pointer over a tool or click a menu item, the Status Bar at the bottom of the Ansoft HFSS window provides a brief description of the function of the tool or menu item.
- The Ansoft HFSS Getting Started guide provides detailed information about using HFSS to create and solve 3D EM projects.

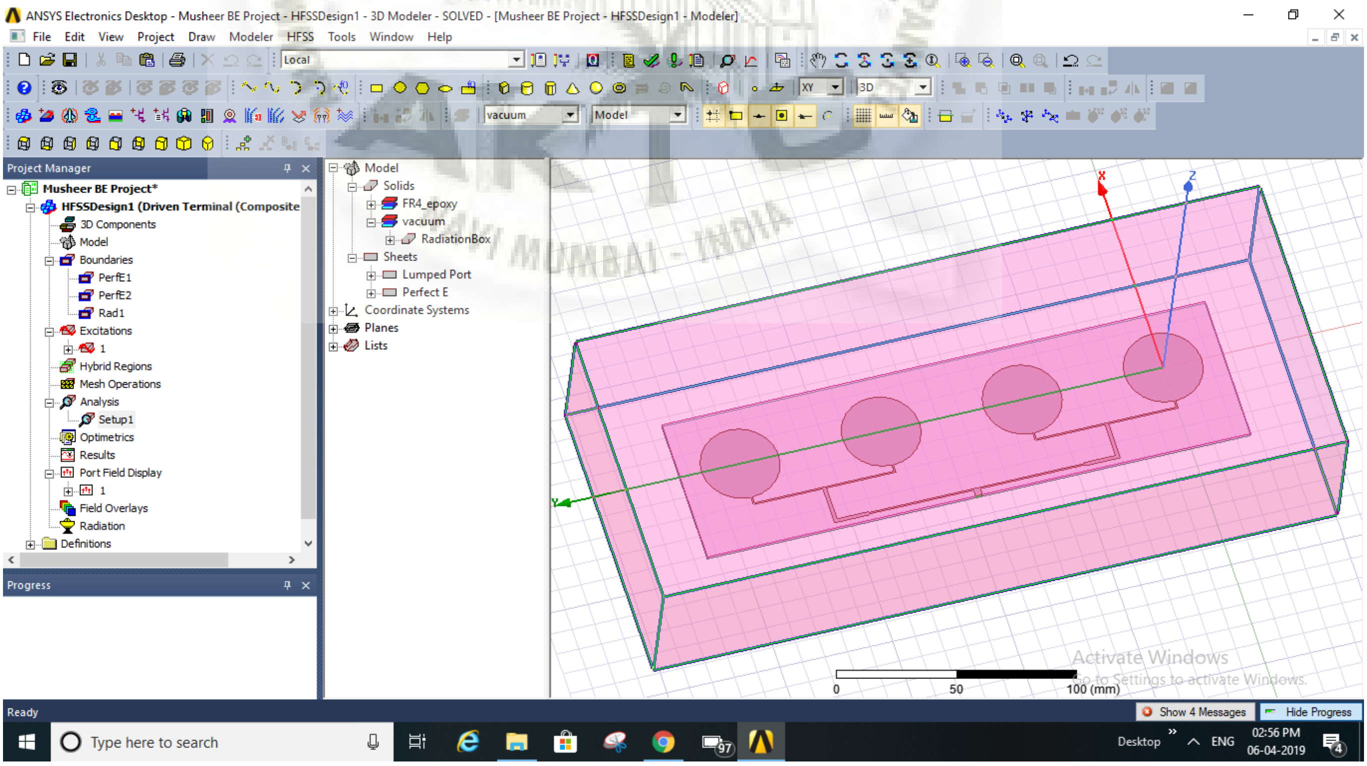
Chapter 4

Results and discussion

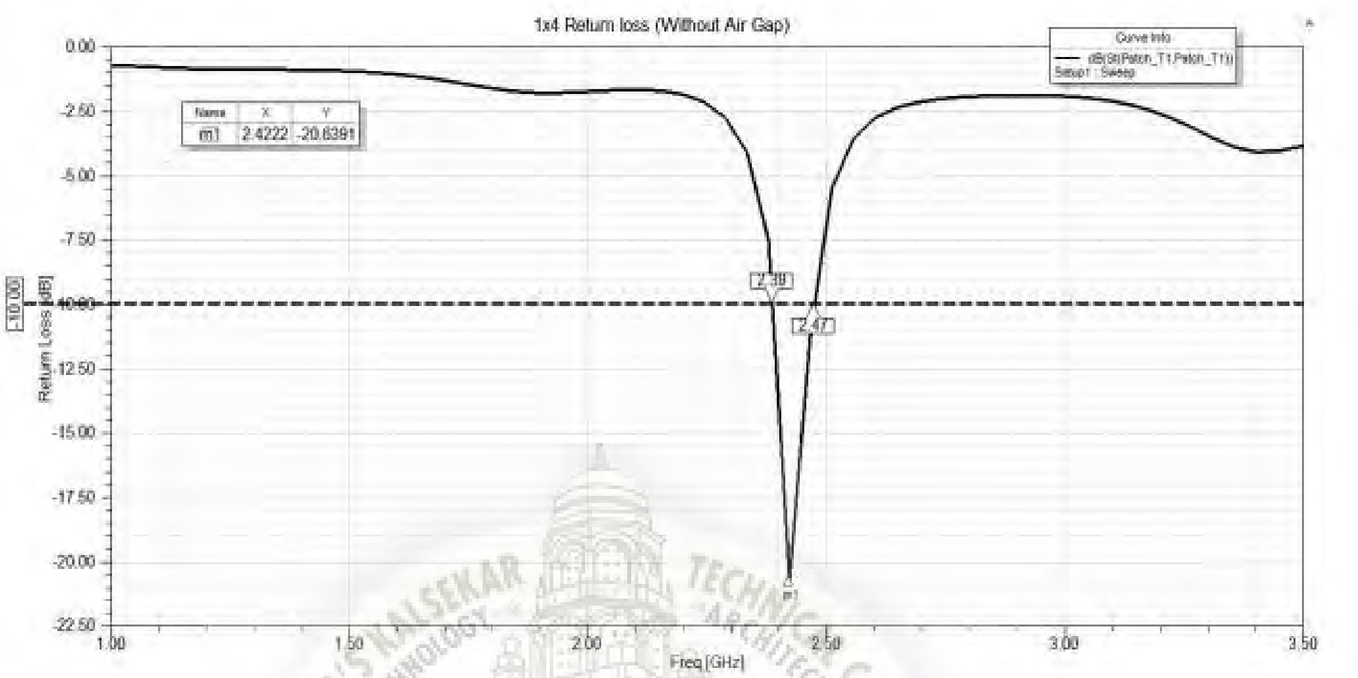
4.1 Simulation Results

In this chapter we will discuss about the effects of various shapes of a microtrip patch array antenna. We will also see that the bandwidth will be increased when we will used different types of patch array. For design simulation we used HFSS (High Frequency Structural Simulator).

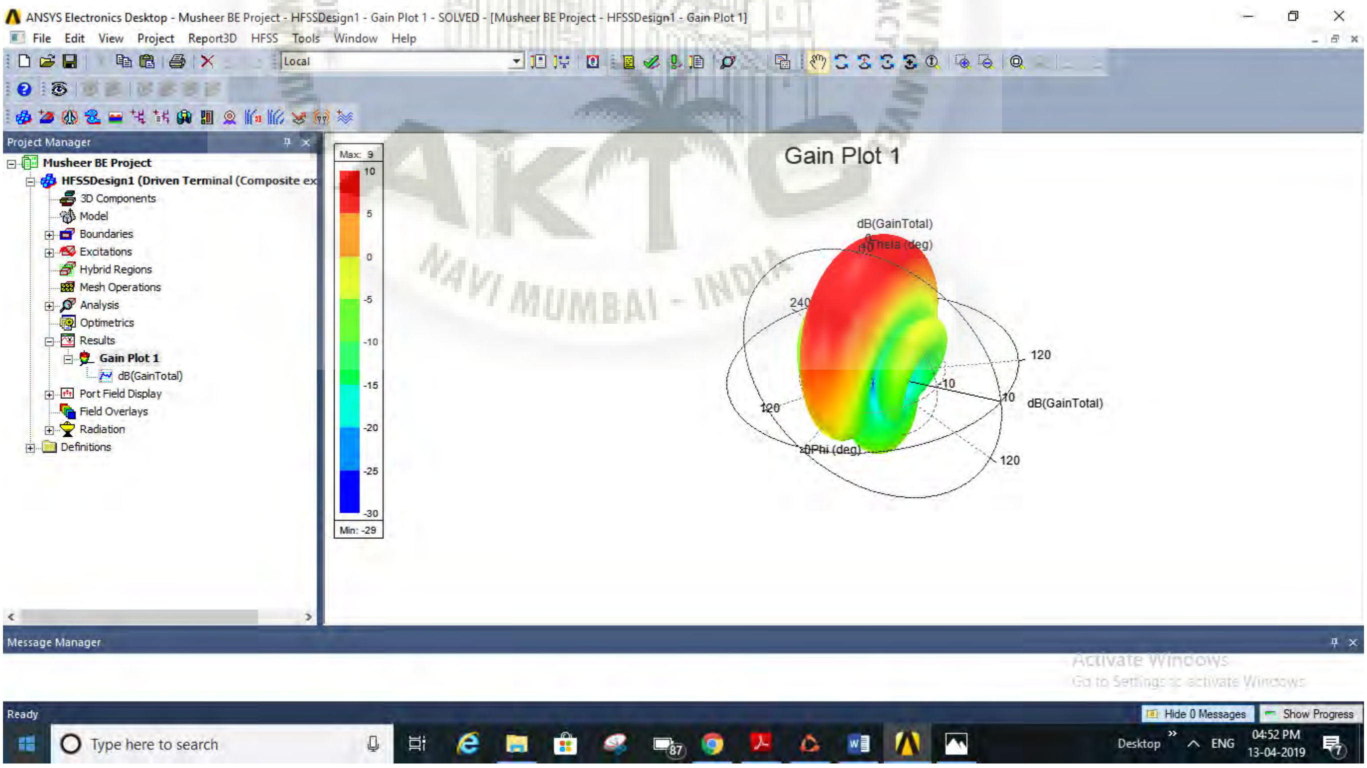
4.1.1 Design and simulation of microstrip patch antenna:



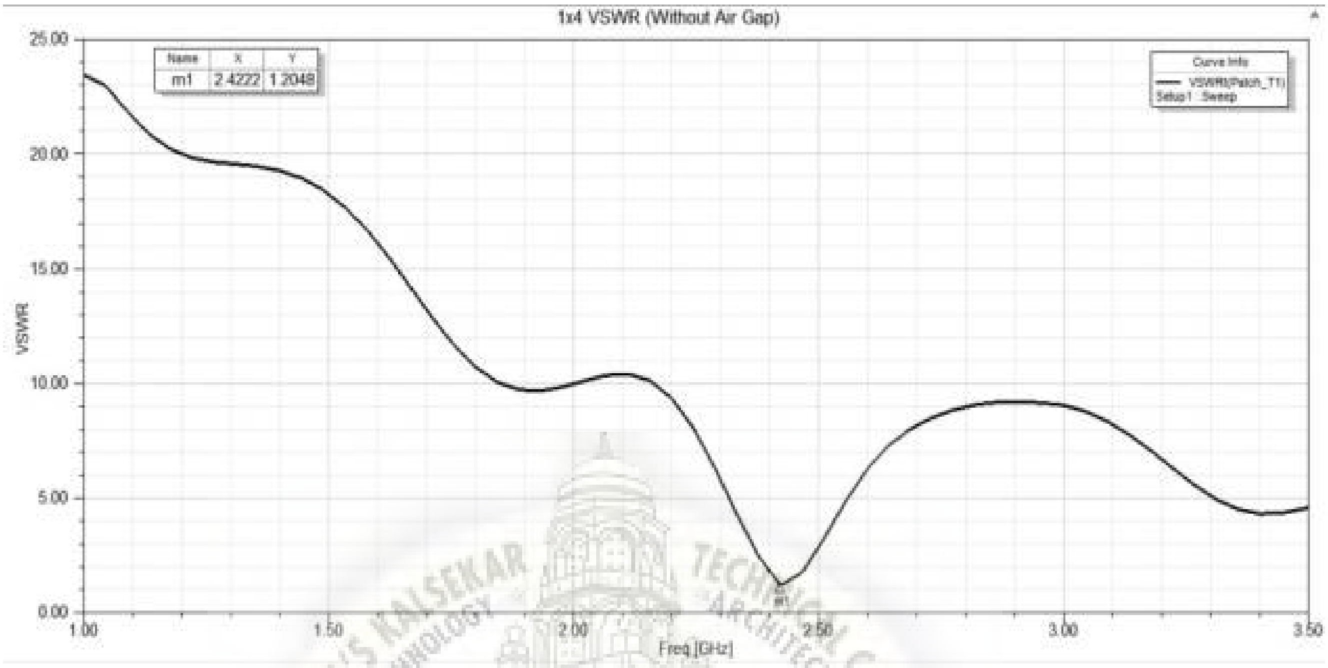
4.1.2 Return Loss of Circular 1x4 Microstrip Patch Antenna:



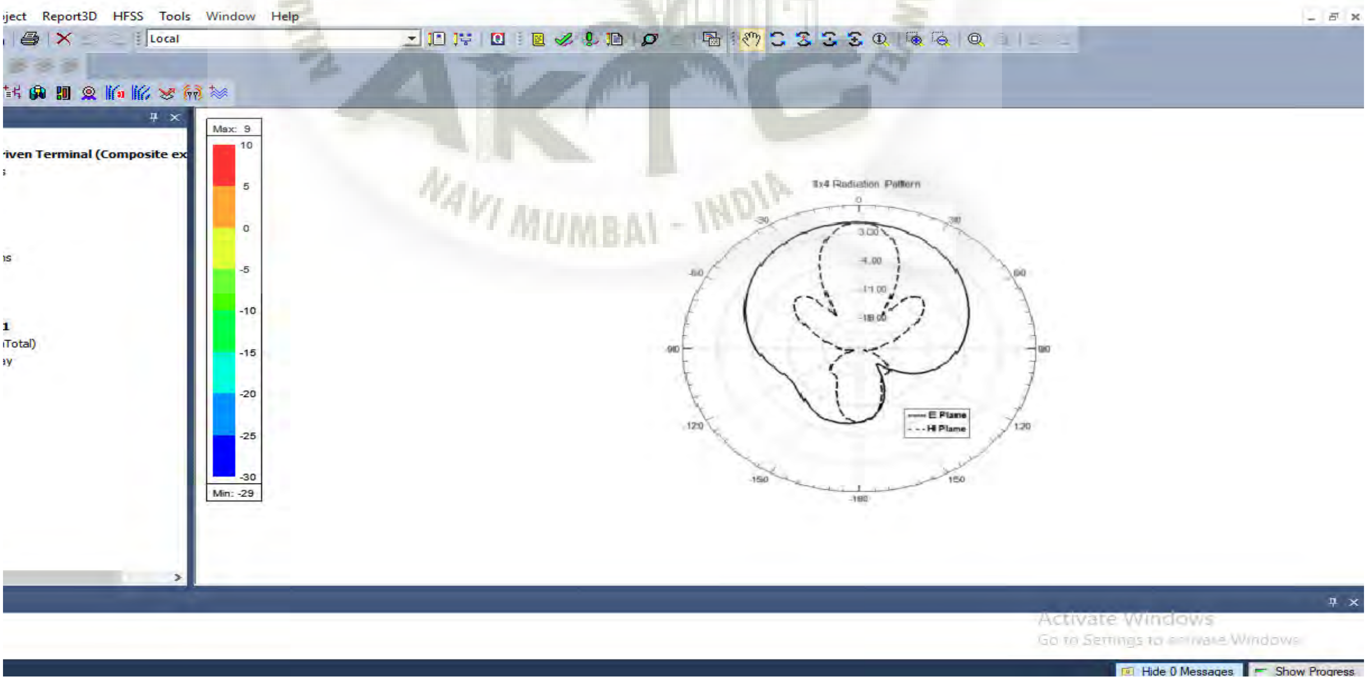
4.1.3 3D Polar Plot for Gain:



4.1.4 VSWR of 1x4 patch array antenna:



4.1.5 Radiation Pattern of Circular 1x4 Microstrip Patch Antenna:



4.1.6 Hardware Simulation:

The geometrical structure under consideration of circular patch antenna prototype and superstrate material is shown in Fig 4.1.6 (a) & (b). A circular patch of radius is 17mm on thick substrate with a dielectric constant 4.4 was fabricated. The patch was fed through probe of 100 Ohm cable.

Fig 4.1.6(a): Fabricated Proto type 1x4 Circular patch antenna (Front Side)

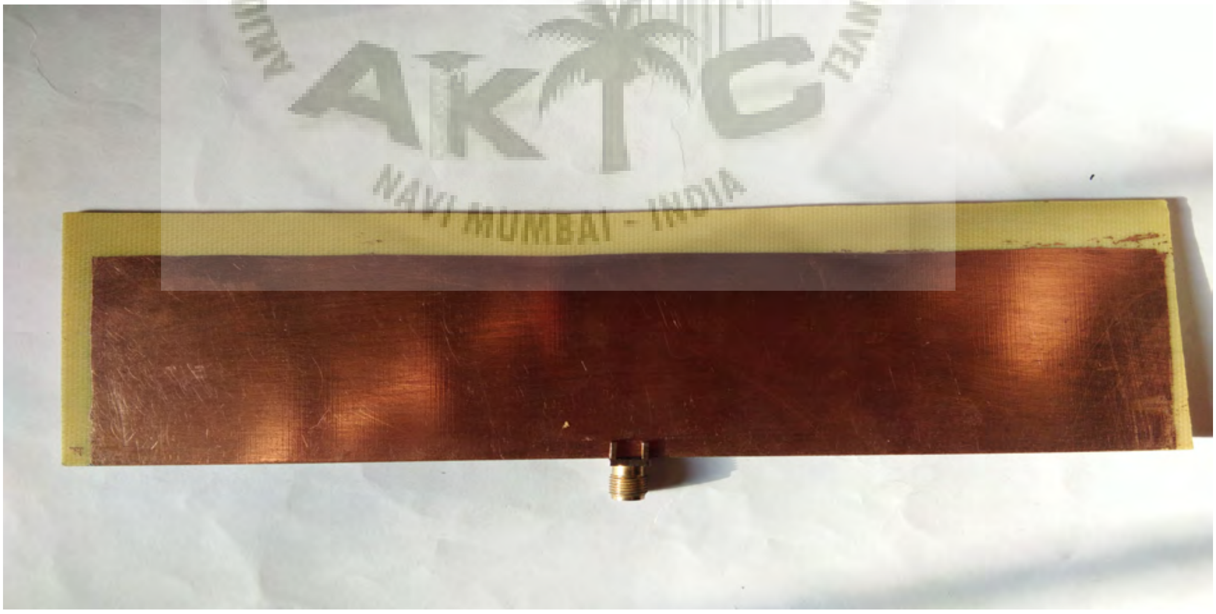


Fig 4.1.6(b): Fabricated Proto type 1x4 Circular patch antenna (Back Side)

Chapter 5

Benefits and Limitations

5.1 Benefits of the Proposed System:

- Ease of manufacturing
- It has a low fabrication cost
- Microstrip patch antennas are efficient radiators
- It has a support for both linear and circular polarization
- Easy in integration with microwave integration circuits
- Unlike linear arrays, distortions in the array pattern of a circular array due to mutual coupling effect are same for each element and this makes it easier to deal with the mutual coupling effects.
- Capable of dual and triple frequency operations.
- High performance
- Supports both, linear as well as circular polarization.

5.2 Limitations

- The spurious radiation exists in various microstrip based antennas such as microstrip patch antenna, microstrip slot antenna and printed dipole antenna.
- It offers low efficiency due to dielectric losses and conductor losses.
- It has higher level of cross polarization radiation.
- It has lower power handling capability.
- It has inherently lower impedance bandwidth.

Chapter 6

Conclusion

Microstrip patch antenna arrays of circular shaped radiating elements were successfully designed and implemented using the FR4 Epoxy Glass substrate. Through the Analysis of HFSS simulation software, it was observed that the antenna resonated at 2.4 GHz frequency. In this work, edge feed technique was used for the simulation of 1x4 Circular Patch Antenna array, whereas probe feed technique is used for Single Patch Antenna. From the proposed simulation design, the maximum achieved gain was 8.2572 dB of 1x4 Circular Microstrip Patch Array Antenna.

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