East West University

RESEARCH PROJECT

ON

DESIGN SIMULATION AND PERFORMANCE ANALYSIS OF SLOT ANTENNA

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DEDICATIONS

To our respectable parents, who prayed for our success and supported us morally and financially.

ACKNOWLEDGEMENT

Firstly, we would like to express our heartfelt gratitude to my supervisor **PhD**, **Professor M. Mofazzal Hossain, Dept. of Electronics and Communications Engineering-East West University,** for his constant support in order to complete our entire project as well as during our study at EWU.

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We are also extending our gratitude to Dr. Gurudas Manal, Chairperson & Associate Professor, Dept. of ECE, EWU for his resilient support to this project.

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At the end, we are grateful to our beloved parents for their constant contributions, affection and persistence which had always given us mental strength to reach our objectives.

MY ALLAH BLESS YOU ALL

ABSTRACT

The necessity of wide-band wireless communications technology is increasing rapidly to support more users and provide information with higher data transmission rates.

The most suitable technology that gives high data rate could be Ultra-wide band (UWB) and among various types of antennas, slot antenna is considered for use in UWB applications because of its ease of analysis and fabrication, low cost, light Weight, easy to feed and their attractive radiation characteristics.

Although slot antenna has numerous advantages, it has also some drawbacks such as limited bandwidth, and a potential decrease in radiation pattern.

Different techniques for bandwidth enhancement of slot antenna are anticipated in this project. By keeping either of length or width, the percentage bandwidth varies. As the percentage Bandwidth increases, the slot width decreases.

Similar analysis is also shown in figure 4.2, which indicates that small range of slot length (13cm to 14cm) the percentage Bandwidth is much higher. This result is compared to other research findings. This project shows bandwidth values up to 44% where as other research outcome is 50.2%.

The antenna achieved good bandwidth with an overall dimension of 13cm to 14cm with frequency of 1GHz.

HFSS Software is used for the simulation and design calculation of slot antenna.

PROJECT OUTLINE

This project consists of four chapters and is organized as follows:
Chapter one: Describes introduction of basics of antenna and literature review.
Chapter Two: Describes about the configuration of Slot antenna with its characteristics, advantages and disadvantages.
Chapter Three: Defines the Methodology that is used to simulate the result by using High Frequency Simulator Structure (HFSS).
Chapter Four: Conclusion and result analysis with future work proposal.

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1.1 Introduction

Antennas are very important component of communication systems. By the definition, an antenna is a device used to transform an RF signal, traveling on a conductor, into an electromagnetic wave in free space. Antennas demonstrate a property known as reciprocity, which means that antenna will maintain the same characteristics regardless if it is transmitting or receiving. Most antennas are resonance devices, which operate efficiently over relatively narrow frequency band. An antenna must be tuned to the same frequency band of the radio system to which is connected; otherwise the reception and transmission will be impaired. When a signal is fed into an antenna, the antenna will emit radiation distributed in space in a certain way. A graphical representation of the relative distribution of the radiated power in space is called a radiation pattern.

1.2 Different Parameters of Antennas

Antenna can be classified based on Size and frequency of antenna

Antennas used for Very High Frequency (VHF) are different from ones used High Frequency (HF), which in turn are different from antennas for microwave. The wavelength is different at different frequencies, so the antennas must be different in size to radiate signals at the correct wavelength. The antennas works the microwave ranges, especially in the 2.4GHz and 5 GHz frequencies. At 2.4GHz the wavelength is 12.5cm, while at 5 GHz it is 6cm.

Directivity and Gain

The Directive gain of an antenna is a measure of the concentration of the radiated power in a particular direction. It may consider as the ability of the antenna to direct radiated power in a given direction. Directivity can be defined as the ratio of radiation intensity in a given direction to the average radiation intensity. The relationship between gain and directivity includes new parameter (η) which describes the efficiency of the antenna.

$$G = \eta \bullet D \qquad (1)$$

Antenna pattern types

Omni directional Antennas: for mobile, portable and some base station applications the type of the antenna needed has an Omni directional radiation pattern. Omni directional antennas radiate energy equally in all direction. By narrowing beam width in the vertical or elevation plane the gain of Omni directional antenna can be increased. The directional antenna radiates the energy in particular direction. Directional antennas are used in some base station applications where coverage over a sector by separate antennas is desired. Point to point links also benefit from directional antennas. Yagi and panel antennas are directional antennas.

Beam width

The beam width of the antenna can be defined as the angular aperture where the most important part of the power is radiated. Taking the most of the radiated power is not divided into side lobes, and then the directive gain is inversely proportional to the beam width: as the beam width decreases, the directive gain increases.

Side lobes

No antenna is able to radiate all the power in one direction some is radiated in other directions. The peaks are referred to as Side lobes.

Nulls

The radiation pattern of an antenna, a null is defined as a zero in which the effective radiated power is at a minimum. A null has a narrow directivity angle compared to that of main beam. Thus the null has many advantages such as suppression of interfering signals in a given direction.

1.3 Types of antennas

There are many different types of antennas like:

- ¼ Wavelength Ground Plane
- Dipole Antenna
- Yagi Antennas
- Log –periodic Antennas
- Horn Antennas
- Parabolic Dish Antennas
- Slotted Antennas
- Micro strip Antennas

1.3.1 ¼ Wavelength Ground Plane

The ¼ Wavelength Ground Plane Antenna is a simple and effective antenna that can capture signal quality from all directions. This kind of antenna is very simple in construction and is useful for communications when size, cost and ease of construction are important. This antenna is constructed to transmit a vertically polarized signal. It consist of a ¼ wave element as half Dipole and three or four ¼ wavelength ground element bent 30 to 45 Degrees down . This set of elements, called Radials, is known as a ground plane. This antenna is used in a Point-to- Multipoint situation, if all other Antennas are also at the same height. The gain of this antenna is in the order of 2-4 dBi.

Figure 1.1: ¼ Wavelength Ground Plane

1.3.2 Dipole and Monopoles Antenna

The vertical Dipole –or its electromagnetic Equivalent, the monopole antenna is considered one of the best antennas for Land Mobile Radio System (LMRs). Its Omni directional (in a Azimuth), if it's a half wavelength long has a gain of 1.64 (or G=2.15) in the horizontal plane. A center- fed, vertical dipole is illustrated in figure 2 (a) although this is a simple antenna, it can be difficult to mount on a mast or vertical.

The ideal vertical monopole is illustrated in figure 2(b). Its half a dipole placed in half spaced, with a perfectly conducting, infinite surface at the boundary.

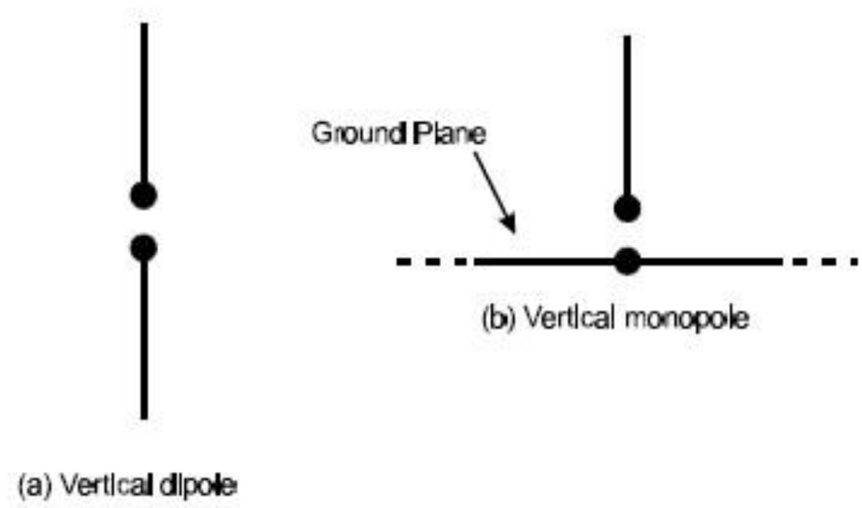


Figure 1.2: The vertical Dipole and its Electromagnetic equivalent, the vertical Dipole.

1.3.3 Yagi Antenna

Another antenna that uses passive elements is Yagi Antenna. A yagi antenna is the equivalent of a center –fed, half wave dipole antenna. Parallel to the driven element and approximately 0.2 to 0.5 wavelengths on either side of it, are straight rods or wires called reflectors and directors or passive elements all together. A reflector is placed behind the driven element and is slightly longer than half wavelength; a director is placed in front of the driven element and is slightly shorter than half wavelength.

A Yagi Antenna may have one reflector and one or more directors. The antenna propagates Electromagnetic field energy in the direction from driven element toward the directors and is most sensitive the incoming electromagnetic field energy in the same direction. The more directors a Yagi has, the greater the gain. Figure (3) shows Yagi Antenna with one reflector, a folded-dipole active element and seven directors mounted for horizontal polarization.

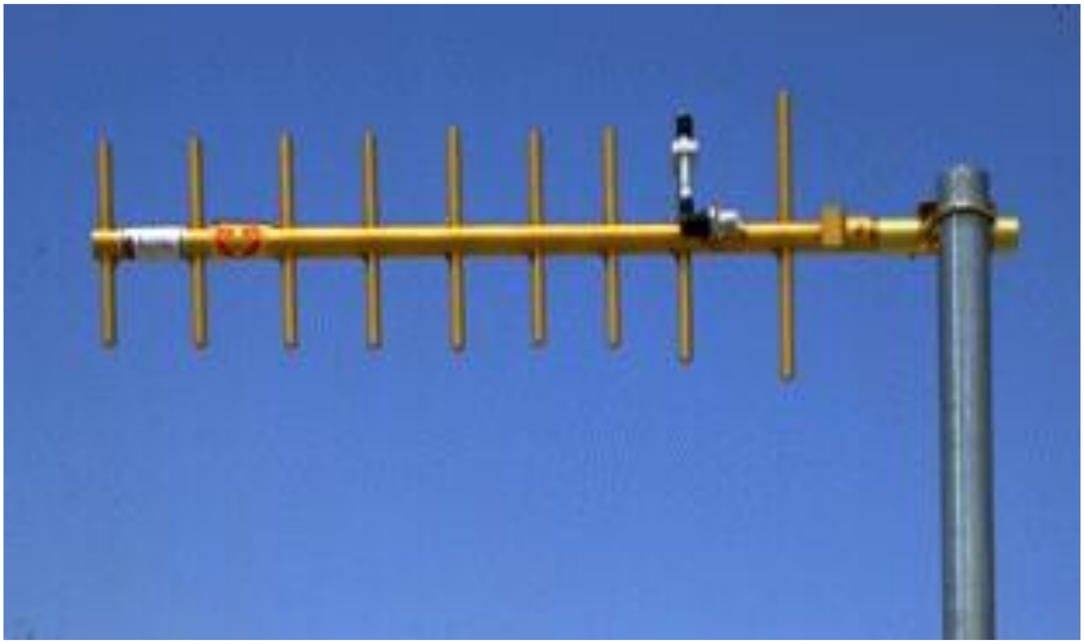


Figure 1.3: A typical Yagi Antenna

Yagi Antennas are used for Point- to- Point Links, have gain from 10 to 20dBi, and have a horizontal beam width of 10 to 20 degrees.

1.3.4 Log- periodic Antennas

The log-periodic Antenna is very useful antenna design based on the dipole element. It’s in fact comprised a set of dipoles, all active, that vary in size from smallest at the front to largest at near. Usually, this antenna is constructed so the antenna terminals are located at the front (on the shortest dipole). Figure 4 shows a typical log- periodic antenna. The key features of this antenna are, first of all, its broadband nature, and the second, its relatively high front-to- back gain ratio. The later feature is evident in the typical radiation pattern as figure 5 shows.

Figure 1.4: A typical Log-periodic Antenna

One of the major drawbacks with many RF antennas is that they have relatively small Bandwidth. This is particularly true of the Yagi Beam antenna. The log-periodic antenna is able to provide directivity and gain while being able to operate over a wide bandwidth. The log-periodic Antenna is used in a number of applications where a wide bandwidth is required along with directivity and a modest level of the gain.

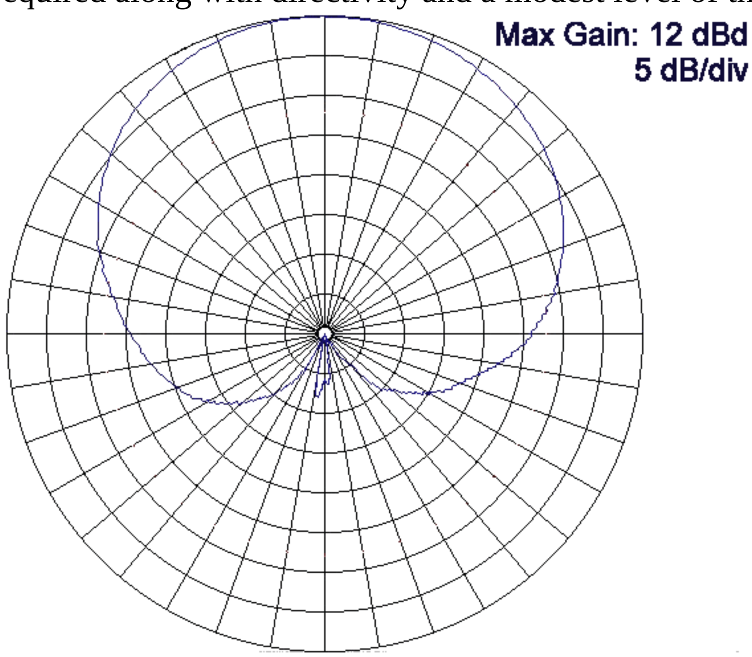


Figure 1.5: A log- periodic antenna Horizontal Plane Pattern

1.3.5 Horn Antennas

The horn antenna is used in the transmission and reception of RF microwave and is normally used in conjunction with waveguide feeds. The horn antenna derives its name from characteristic flared appearance, launching the signal towards the receiving antenna. Horn Antennas are commonly used as the active element in a dish antenna. The horn antenna is pointed toward the center of dish reflector. Horn antennas are often used as gain standards, and as feeds for parabolic or dish antennas, as well as being used as RF antennas in their own right. One particular use of horn antenna is for short range radar systems. The main advantage of the horn antenna is that it provides a significant level of directivity and gain. For greater levels of gain the horn antenna should have a large aperture. Also to achieve the maximum gain for a given aperture size, the taper should be long so that the phase of the wave-front is as nearly constant as possible across the aperture.

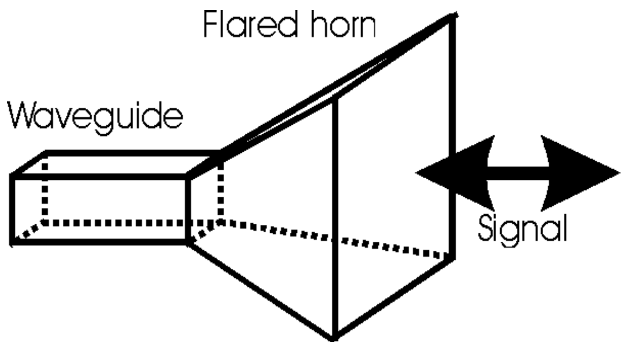


Figure 1.6: **Horn antenna used for RF microwave applications**

Figure 1.7: A typical Horn Antenna

1.3.6 Feed horns

A waveguide horn, called a feed horn, may be used to feed energy in to a parabolic Dish. The directivity of this feed horn is added to that of parabolic dish. The resulting pattern is a very narrow and concentrated beam. In most radar, the feed horn is converted with a window polystyrene fiberglass to prevent moisture and dirt from entering the open end of the waveguide.
One problem associated with feed horns is the shadow introduced by the feed horn if it is in the path of the beam.(Shadow is the dead spot directly in front of the feed horn.) To solve this problem the feed horn can be offset from center. This location change takes the feed horn out of the path of the RF beam and eliminates the shadow.

1.3.7 Parabolic Dish Antenna

The parabolic reflector antenna or Dish Antennas are the most common type of directive antennas when a high gain antenna is required. However the Dish antenna finds uses in many radio and wireless applications at frequencies usually above 1 GHz where very high levels of RF antenna gain are required along with narrow beam width.The basic characteristics of a perfect parabolic reflector is that it converts a spherical wave irradiating from a point source placed at the focus into a plane wave. Conversely, all the energy received by the Dish from a distant source is reflected to a single point at the focus of the Dish.

Figure1.8: A typical parabolic reflector antenna

1.3.7.1 Advantages and Disadvantages of parabolic antenna

- **High gain:** The parabolic Dish antenna provides high levels of gain. The larger the 'Dish' in terms of wavelengths, the higher the gain.
- **High Directivity:** The parabolic reflector or 'Dish' antenna is able to provide high levels of directivity. The higher the gain, the narrower the beam width. This can be a significant advantage in applications where the power is required to be directed on over a small area. This prevents interference to the other users.

Disadvantages

- **Requires reflector and derive element:** the parabolic reflector antenna is part of antenna. It requires a feed system to be placed at the focus of the parabolic reflector.
- **Cost:** A parabolic is needed to reflect the radio signals which must be made carefully. In addition to this a feed system is also required. This can add cost to the system.
- **Size:** The antenna is not as small as some types of antenna, although many used for satellite television reception are quite compact.

Applications

- **Direct Broadcast Television:** Direct broadcast or satellite television has become a major form of distribution for television material.
- **Microwave Links:** Terrestrial microwave links are used for many applications. Often they are used for terrestrial telecommunications infrastructure links. One of the major areas where they are used these days is to provide the backhaul for mobile phone / cellular backhaul.
- **Satellite Communications:** communication satellites require high levels of gain to ensure the optimum signal conditions and that transmitted power from the ground do not affect other satellites in close angular proximity.
- **Radio astronomy:** is an area where very high levels of gain and directivity are required.

1.3. 8 Slotted Antennas

Slot Antennas are used typically at frequencies between 300MHz and 24GHz. This kind of antenna is popular because it can be cut out whatever service they

are to be mounted on, and have radiation pattern that are very similar to those of the Dipole antenna. The polarization of the Slot antenna is Linear. Similarly the Azimuth and elevation patterns are similar to those of the Dipole antenna, but its physical construction consists only narrow slot cut in to ground plane.
The characteristics of the slot antennas are differ from other antennas; it provides little antenna gain, and does not exhibit high directionality, as evidenced by their radiation plots and their similarity to the dipoles. The most important feature for slot antenna is the ease with which can be constructed and integrated in to an existing design, and their low cost.

Advantages of Slot Antenna:

- Ease of analysis and fabrication
- Low cost
- Light weight
- Low profile
- Easy to feed and their attractive radiation characteristics.

1.3.9 Micro strip Antennas

Micro strip antennas can be made to emulate many of the different styles of antennas mentioned above. Macro strip antennas offer several tradeoffs that need to be considered. Because it can be manufactured with PCB traces on actual PCB (Printed Circuit Boards), and it's very small and lightweight. The Micro strip antennas are made very specific frequency range. In many cases, limiting the frequencies that can be received is actually beneficial to the performance of radio. Due to this characteristic, micro strip antennas are made are not well suited for Wide Band Communications System.

Advantages

Micro strip antennas are widely used in satellite communications, military purposes, GPS, mobile and Missile systems.

- Ease of manufacturing
- It has a very low fabrication cost
- Micro strip patch antennas are efficient radiators.
- It has a support for both linear and circular polarization
- Ease in integration with microwave integration circuits.

Disadvantages

- Low impedance Bandwidth
- Low Gain
- Extra radiation occurs from its feeds and junctions
- The size of micro strip antenna comes in both advantages and disadvantages but there are some applications where the size of micro strip antenna is too large to be used.

Chapter Two
Configuration of Slot Antennas

2.1 Introduction

Firstly, the necessity of wideband wireless communications technology is increasing rapidly due to the need to support more users and to provide information with higher data transmitting rates. Ultra-wideband (UWB) technology could be the most suitable technologies that promise to revolutionize high data rate transmission and enable the personal area networking industry leading to new innovations and greater quality of services to the end users. A UWB system is found to be extremely useful and consists of various satisfying features such as high data rate, high precision ranging, fading robustness, and low cost transceiver implementation. UWB is regarded as a very encouraging and fast emerging low-cost technology with uniquely attractive features inviting major advances in wireless communications, sensor networking, radar, imaging, and positioning systems [1].

Antennas are vital elements of any wireless communication systems. For UWB communication systems, the antennas must be of low profile, light weight, low cost, compact size and conformable to the manner of the mounting devices.

Currently, slot antennas are under consideration for use in UWB applications and are getting more general because of the qualities of wide frequency bandwidth, low profile, lightweight, ease of fabrication and integration with other devices or RF circuitries.
In comparison with other antennas, slot antennas have relatively large magnetic fields that do not to couple strongly with near-by objects, which make them suitable for applications wherein near-filed coupling is required to be minimized.
Slot antennas are general Omni directional microwave antennas. These antennas feature Omni directional gain around the azimuth with horizontal polarization.

Waveguide slot antennas, usually with an array of slots for higher gain are used at frequencies from 2 to 24 GHz, while simple slotted-cylinder antennas are more common at the UHF and lower microwave frequencies where the size of a waveguide becomes unwieldy.

There are two types of slot antenna in terms of bandwidth. Narrow-slot antenna which has limited bandwidth and wide-slot antennas provides wider bandwidth.

Moreover, it has been found that slot antennas have wide bandwidth characteristics. By applying different tuning technique or by using different slot shapes such as rectangle, circle, U-shaped, different slot antennas attained. We will discuss this chapter on slot antenna having enough impedance bandwidth with Omni directional radiation which is proposed for UWB communication systems. By designing a micro strip fed rectangular tuning stub as radiating element and a narrowing shape slot in the ground plane, the proposed antenna achieved a UWB characteristics.

2.2 Configuration of Slot antenna

The configuration of antenna contains of a narrow shape slot fixed out of ground plane and micro strip line served rectangular tuning stub for excitation. The tuning stub fed by micro strip line of 50 Ω characteristics impedance is printed on one side of an inexpensive FR4 substrate of thickness 1.6 mm, with relative permittivity 4.6 and loss tangent 0.02 while the slot is etched out on the other side. The reason for choosing FR4 substrate material is its low cost. Despite of relatively high loss tangent, the antenna fabricated on FR4 achieved reasonable gain and efficient, which are sufficient for UWB wireless communications. The slot in the ground plane consists of two parts: The Rectangular part of dimension W3×L1 and the Triangular section, which is shaped with angle of 90 degree for a length *L2* and has strong coupling to the feeding structure. The distance between bottom edge and lower edge of the slot is *h*. therefore, by properly selecting the shape and tuning stub, a good impedance bandwidth and radiation characteristics can be achieved.

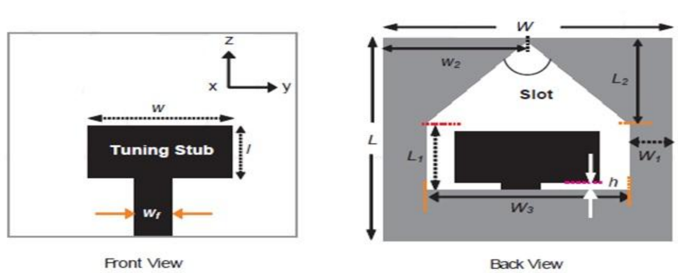


Figure 2.1 Geometry and view of the slot antenna.

2.3 Effects of the tuning stub

To get a higher level of electromagnetic coupling to the tuning stub, a wide slot antenna is used. Therefore, variation of tuning stub shape will change the coupling; thus control the impedance matching. Different shapes are studied to enhance the coupling between micro strip-line and tapered slot. Due to poor electromagnetic coupling between feed-line and tapered slot, the impedance matching will be very poor.

The rectangular shape tuning shows a good coupling with tapered shape. Moreover, it provides a wider impedance matching for UWB application.

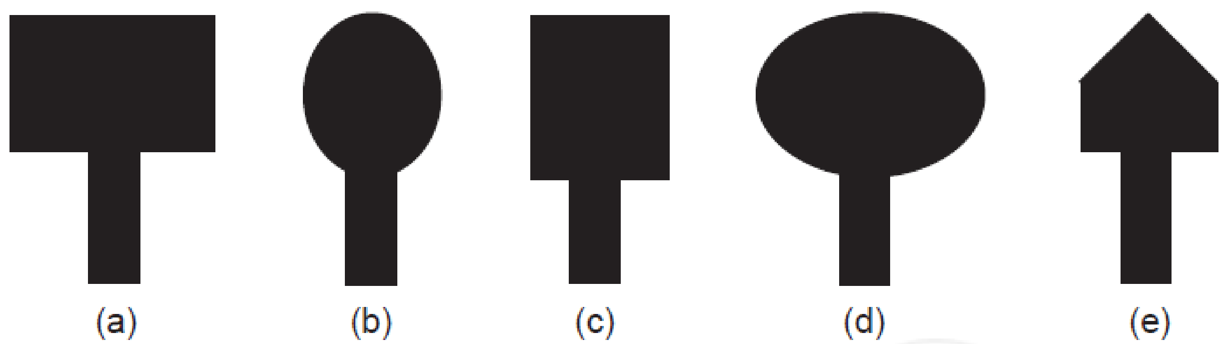


Fig2.2. Different tuning stub shapes a) Rectangular b) circular c) Square d) Elliptical e) Tapered

2.4 Effects of slot shape

The operating bandwidth of wide-slot antenna is limited due to the degradation of the radiation patterns at higher frequencies, but it is known that it has a wide impedance bandwidth.

Through the numerical study on different slot shapes as shown in Figure 3, it is seen that currents flowing on the edge of the slot will increase the cross-polarization component in the *yz*-plane and cause the main beam to tilt away from the broadside direction in the *pl*ane.

Unlike the conventional wide-slot antenna, the slot in the ground plane of the proposed antenna with tapered shape is surrounded by ground strips of small width, which makes the antenna very compact. Moreover, introduction of the tapered slot instead of the rectangular slot changes the electric field distribution by reducing the longest current path and reducing the slot size. As a result, the impedance matching is much improved, especially at lower frequencies, resulting in overall enhancement of operating bandwidth as shown in Figure 5. It is also observed that high-frequency performance can also be employing tapered slot structure, and a tapered-shape slot matched with a rectangular tuning stub can produce wider bandwidth than with a circular, elliptical, and square-shaped slot.

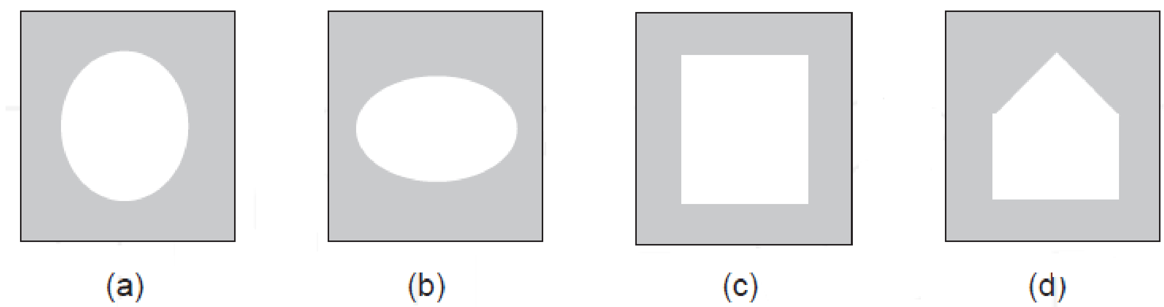


Figure 2.3 Different slot shape a) Circular b) Elliptical, (c) Square and (d) Tapered.

2.4 Slot Antennas Construction:

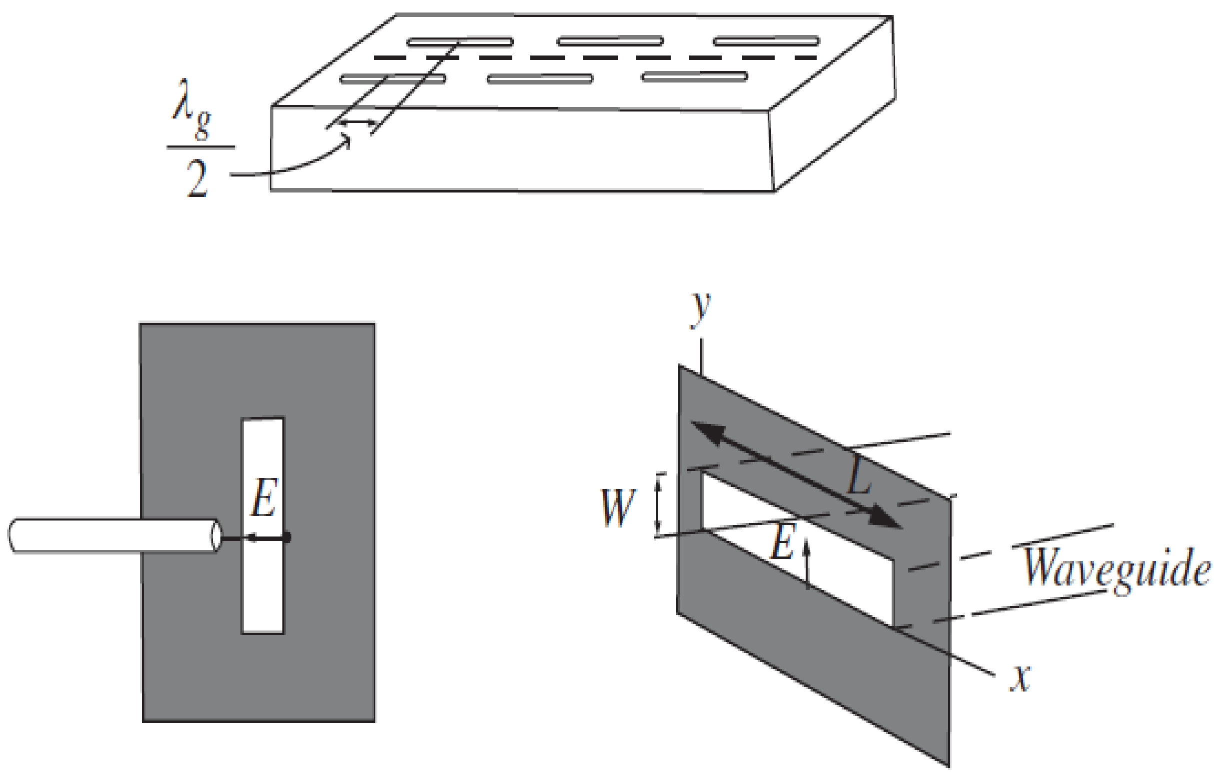


Figure 2.4. Construction of slot antenna

Normally it is low-profile and can be conformed to basically any configuration, thus they have found many applications, for example, on aircraft and missiles. Moreover, slot waveguide antenna array are widely used for radar.

The equivalent circuit can be shown below:

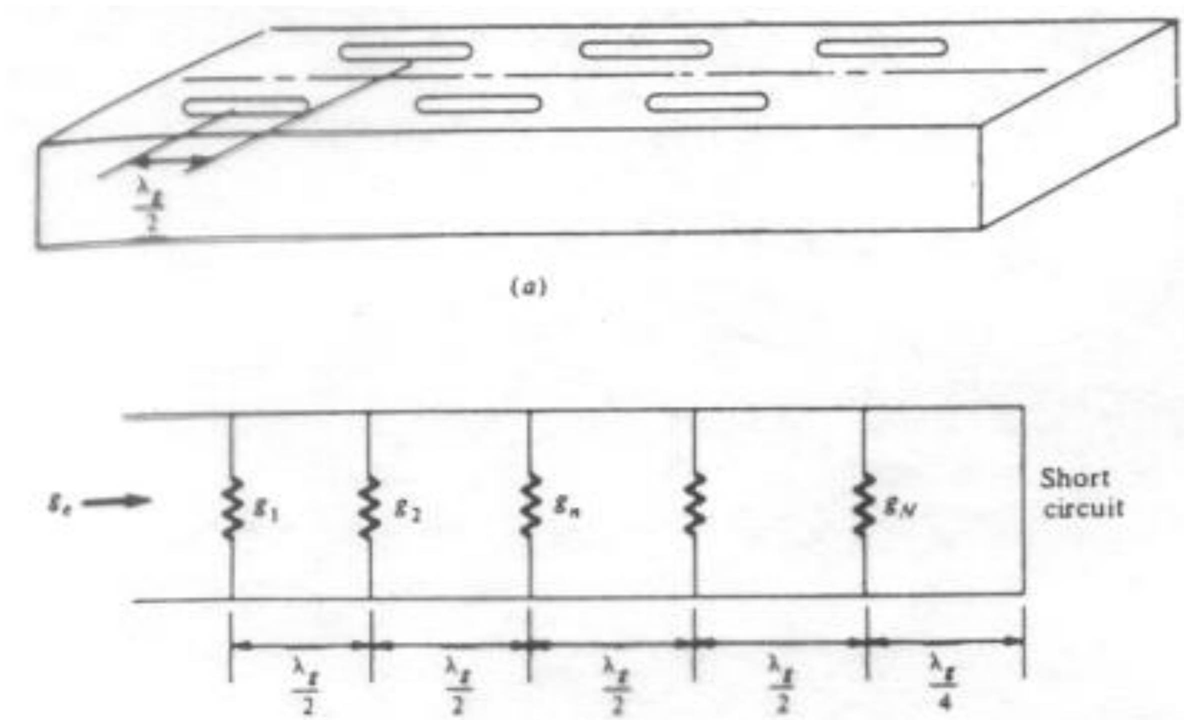


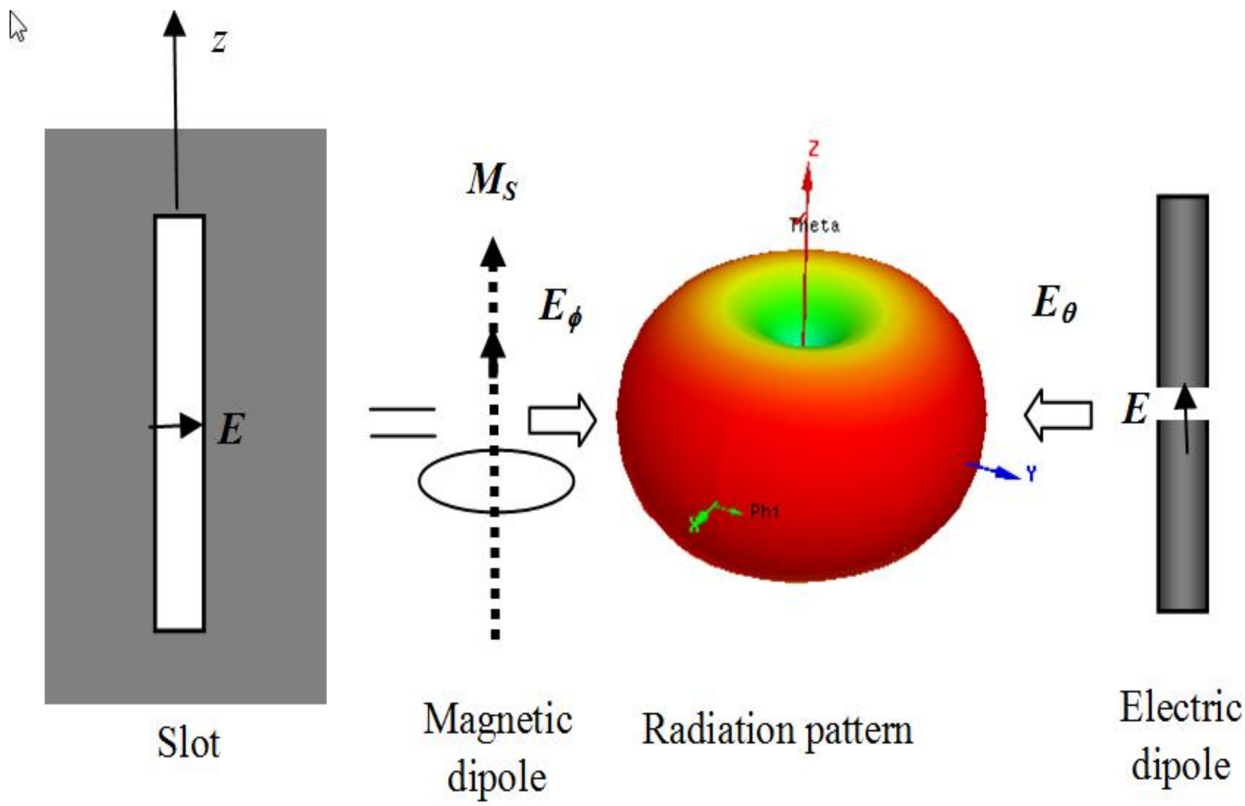
Figure 2.5 (a) Equivalence Circuit

Equivalence Principle for field analysis:

The radiated field by the slot is the same as the field radiated by its equivalent surface electric current and magnetic current which were given by

$$\boldsymbol{J}_S = \hat{\boldsymbol{n}} \times \boldsymbol{H}, \ \ \boldsymbol{M}_S = -\hat{\boldsymbol{n}} \times \mathbf{E}$$

Where *E* and *H* are the electric and magnetic fields within the slot, and $\hat{\mathbf{n}}$ is the unit vector normal to the slot surface S.



A resonant narrow slot antenna is correspondent to a magnetic dipole, and at its first resonant frequency it has an equivalent length of $\lambda g/2$, λg is the guided wave length in the slot.
If the slot antenna is applied near an edge by a micro strip line and the slot width is well chosen, at a frequency above the first slot resonance, a fictitious short circuit near the micro strip feed may be created. Mostly the tangential component of the electric field created by the micro strip line at a particular distance cancels out the electric field of the slot excited by the return current on the ground plane of the micro strip line. A full wave simulation shows the field distribution for this situation in Fig. 2.5 (b), whereas fig2.5 (a) shows the electric field distribution in slot at its first resonance. The slot width, the width of micro strip feed, and distance between the center of the micro strip and the edge of the slot antenna Ls are parameters that affect the existence and location of short circuit. As the Ls increases, the second resonant frequency also increases. By choosing Ls properly, the second resonant frequency can be chosen such that the total antenna bandwidth can be increased or dual-band operation can be attained. However, the overall effective antenna is determined by the frequency of the first resonance. It can be seen from the first figure, the electric field distribution of second resonance is similar to that of first one. For that reason, it is predictable that the radiation patterns of the antenna are similar.
In order to experiment this concept, we shall discuss more deeply to the next chapter of Designing analysis of slot antenna.

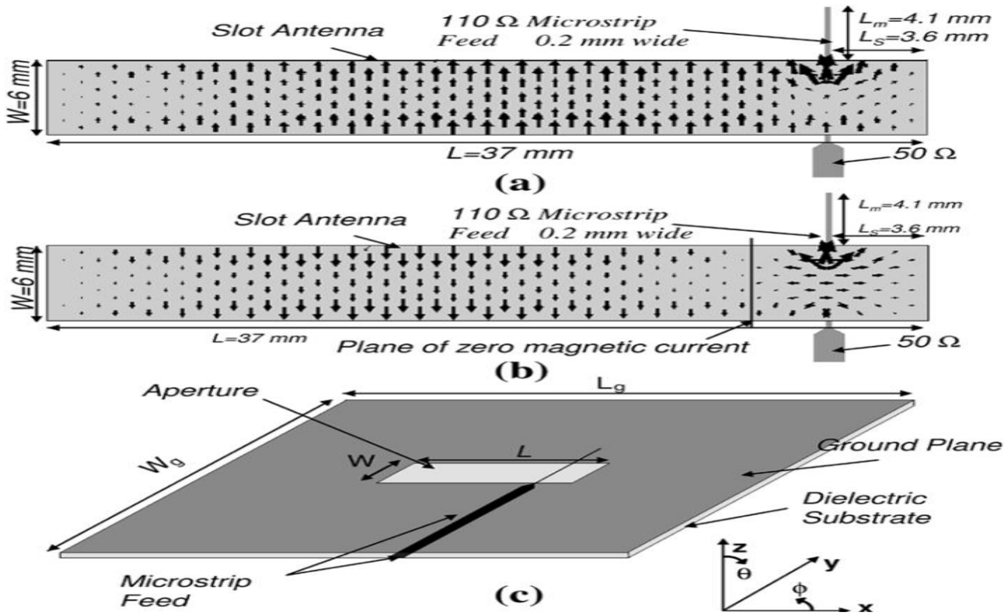


Figure 2.6. Electric field distribution and three-dimensional geometry of 0:08 wide micro strip-fed slot antennas. (a) Normal field distribution. (b) Field distribution at a slightly higher frequency showing a fictitious short circuit along the slot causing the second resonance. (c) Three-dimensional geometry.

Chapter Three
Methodology

By using HFSS Software we will simulate and design calculation of Micro strip slot antenna. The return loss, VSWR curve, directivity and gain are to be analyzed and evaluated.

3.1 Introduction

A patch Antenna **(**also known as a rectangular micro strip antenna) is types of radio antenna with allow profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called Ground plane. The assembly is usually contained inside a plastic redone, which protects the antenna structure from damage. Patch antennas are simple to fabricate and easy to modify and customize. They two metal sheets together form a resonant piece of micro strip transmission line with a length of approximately one-half wavelength of the radio waves. A patch antenna is usually constructed on a dielectric substrate, using the same materials to make printed circuit board.

3.2 High Frequency Simulator Structure (HFSS)

HFSS is a high performance full wave Electromagnetic (EM) field simulator for arbitrary 3D volumetric positive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface.

It integrates simulation, visualization, solid modeling, and automation in an easy to learn environment where solutions to 3D EM problems the Finite Element Method (FEM), adoptive meshing, and brilliant graphics to give us unparalleled performance and insight to all of 3D EM problems.

3.3 Applications of HFSS

Ansoft HFSS can be used to calculate parameters such as S-Parameters, Resonant Frequency, and Fields. Typical uses include:

- Package Modeling – BGA, QFP,Flip-Chip
- PCB Board Modeling – power/ Ground planes, Mesh Grid Grounds, Backplanes.
- Silicon/GaAs-Spiral Inductors, Transformers. EMC/EMI- Mobile Communications-patches, Dipoles, Horns, Conformal Cell Phone Antennas, Infinite Arrays, Radar Section (RCS), Frequency Selective Surface (FSS).
- HFSS is an interactive simulation system whose basic mesh element is a tetrahedron. This allows solving any arbitrary 3D geometry, especially those with complex curves and shapes, in a fraction of the time it would take other techniques.

- The name HFSS stands for High Frequency Structure Simulator. Ansoft pioneered the use of the Finite Element Method (FEM) for EM simulation by developing / implementing technologies such as tangential vector finite elements, adoptive meshing, and Adoptive Lancozos –pade Sweep(ALPS).

- Ansoft HFSS has evolved over a period of years with input from many users and industries . In industry, Ansoft HFSS is the tool of choose for high productivity research, development, and virtual prototyping.

  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.

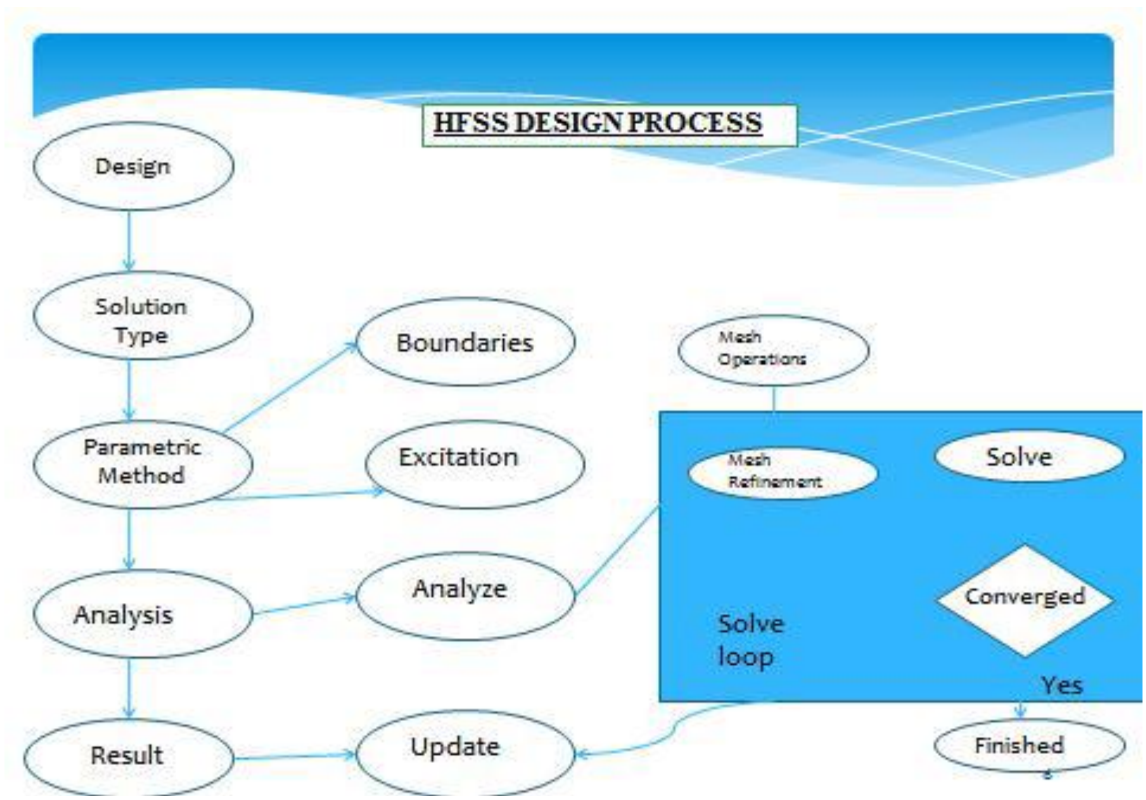


Figure 3.1: HFSS design process

3.4 Patch antenna details

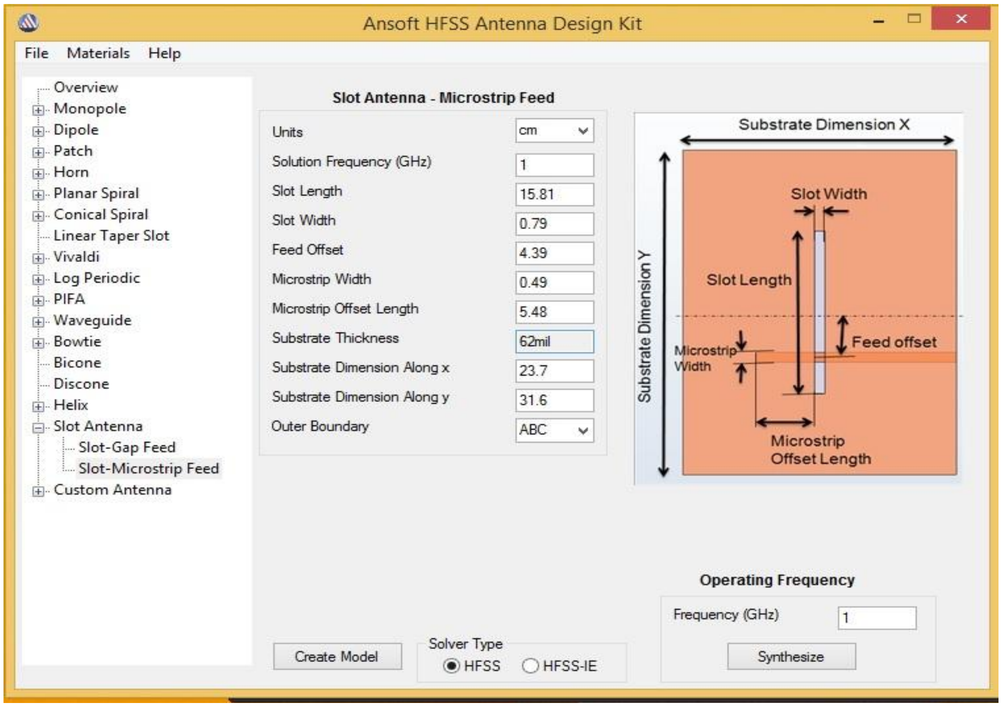


Figure 3.2: Dimensions of antenna

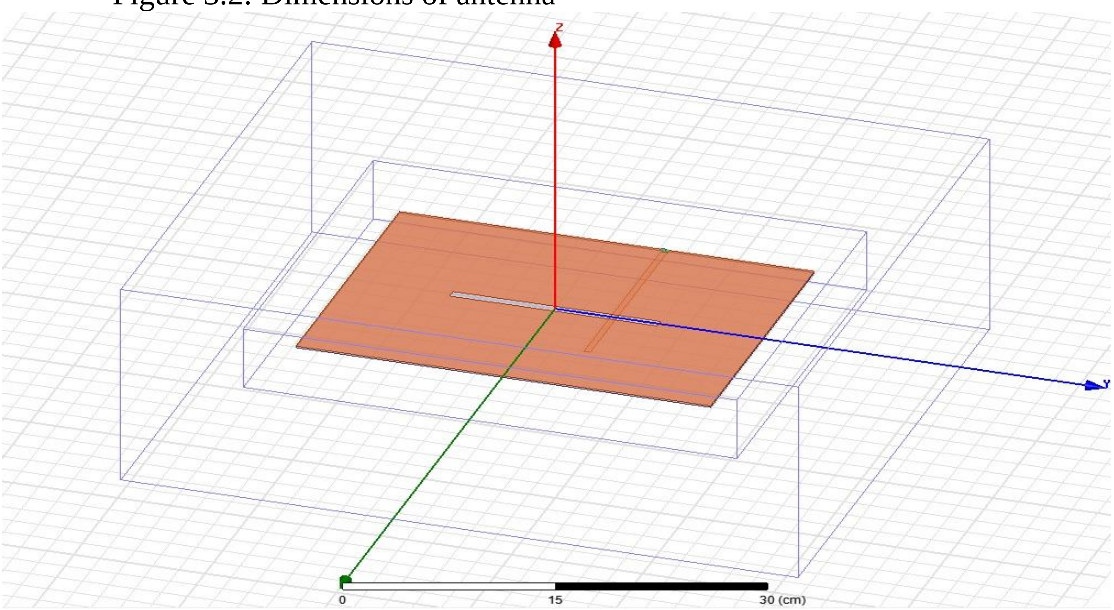


Figure 3.3 Final Geometry of slot antenna Design

Chapter Four
Result and Discussions

Table 1: Slot Length and Percentage Bandwidth

Serial	Slot Length in (cm)	Slot Width in (cm)	% Bandwidth
1	15.81	0.79	15.79
2	15.6	0.79	13.4
3	15.3	0.79	14.78
4	15	0.79	11.73
5	14.5	0.79	7.4
6	14	0.79	3.3
7	13.5	0.79	83
8	13	0.79	5
9	12.5	0.79	2.5
10	12	0.79	10.5
11	11.5	0.79	5.6
13	11	0.79	3.9
14	10.5	0.79	2.3
15	10	0.79	2.34

Table 2: Slot Width and percentage Bandwidth

Serial	Slot Length in (cm)	Slot Width in (cm)	% Bandwidth
1	15.81	0.79	44
2	15.81	0.85	40
3	15.81	0.9	40.12
4	15.81	1	35.8
5	15.81	1.1	30.7
6	15.81	1.2	28
7	15.81	1.3	25.15
8	15.81	1.5	22
9	15.81	1.7	18.58
10	15.81	2	13.6
11	15.81	2.2	7.07

13	15.81	2.5	6.18
14	15.81	3	5.26
15	15.81	3.5	1.6

In figure 4.1, we plot the profile of Slot Width and Percentage Bandwidth. As the Percentage Bandwidth increases the Slot Width decreases. Similar analysis is also shown in figure 4.2, which indicates that small range of slot length (13cm to 14cm) the percentage Bandwidth is much higher.

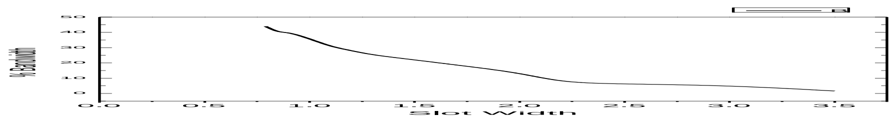


Figure 4.1 the profile of Slot Width

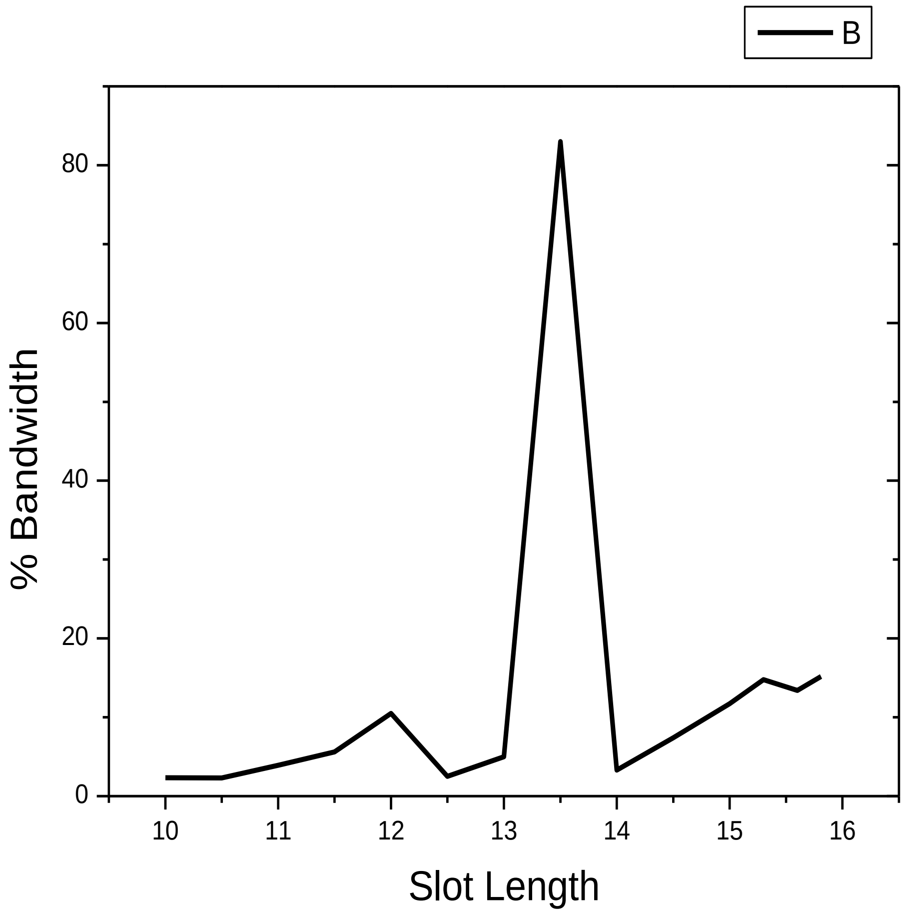


Figure 4.2 the profile of Slot Length

In figure 4.3, shows 3D radiation pattern. In the patterns the red color indicates the stronger radiated E-field and the green color is the weakest ones. At low frequency, the radiation patterns are almost Omni-directional similar to a typical monopole antenna. The radiation is slightly weak in x-direction.

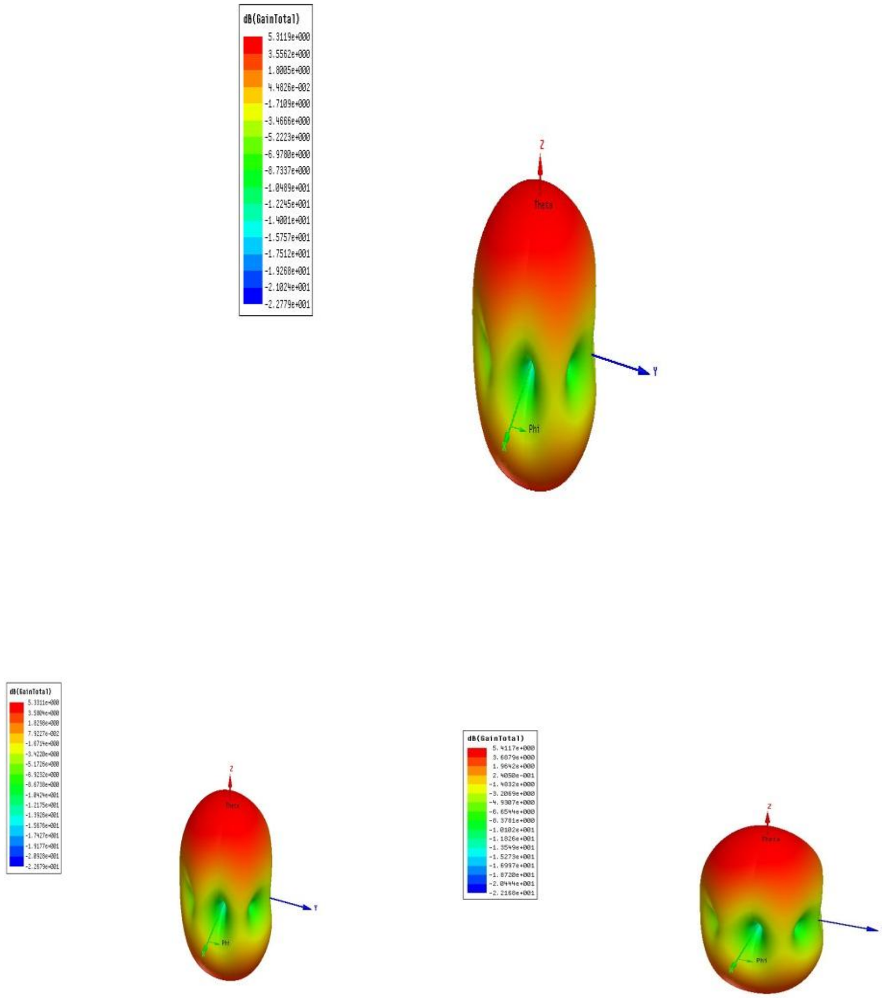


Figure 4.3 measured 3D radiation pattern in xy, yz and xz -planes

Slot Length   L : 15.81cm
Slot Width   W: 0.79 cm   Slot Width :   W: 1.5 cm   Slot Width W: 3.5cm

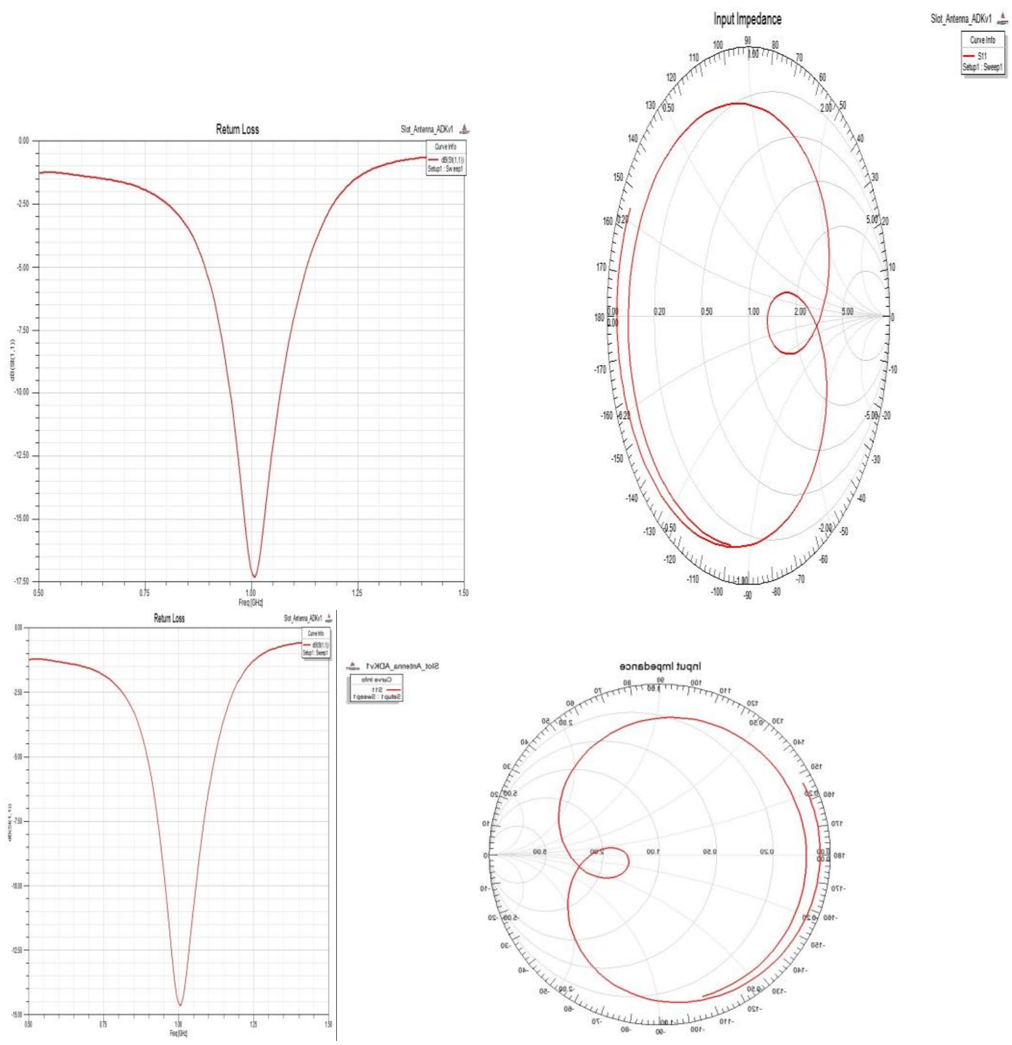


Figure 4.4   Return loss Vs Radiation Pattern

Chapter Five
Conclusion and Future Work

A patch Antenna (also known as a rectangular micro strip antenna) is type of radio antenna with low profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet or “Patch” of metal, mounted over a larger sheet of a metal called Ground Plane. Patch antennas are simple to fabricate and easy to modify and customize. The radiation mechanism arises from discontinuities at each truncated edge of the micro strip transmission line.

A micro strip or patch antenna is a low profile antenna that has a number of advantages over other antennas. Its slight weight, inexpensive, and easy to integrate with accompanying electronics it has also some drawbacks such as restricted bandwidth, and a potential enhancement decrease in radiation patterns. The main objective of this project is to design slot antenna, and increase the percentage bandwidth as much as possible 44% with comparing the existing percentage bandwidth (50.2%). HFSS software is used for the simulation and design calculation of slot antenna.

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