DESIGN AND FABRICATION OF ANTENNA FOR SATELLITE COMMUNICATION

DISSERTATION-II

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IN

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By

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CERTIFICATE

This is to certify that Ankita Bhagat bearing Registration no. 11612565 have completed objective formulation/Base Paper implementation of the thesis titled, **"Design and Fabrication of Antenna for Satellite Communication "** under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of thesis has ever been submitted for any other degree at any university.

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We are also indebted to all authors of the research papers and books referred to, which have helped us in carrying out the research work.

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DECLARATION

I, Ankita Bhagat, student of M. Tech under Department of Electronics and Communication of Lovely Professional University, Punjab, hereby declare that all the information furnished in this Dissertation-II report is based on my own intensive research and is genuine.

This report does not, to the best of our knowledge, contain part of my work which has been submitted for the award of my degree either of this University or any other University without proper citation.

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ABSTRACT

The main objective of this report is to represent the various design implementation using software HFSS. This report also contains all the basics of antenna and its parameters which effects the performance of an antenna. The simulation is done by HFSS and results are analyzed. The main aim is to learn the software and know the various techniques and methods of optimum antenna design. The implemented antennas suits well for various application such as satellite communication, radar communication and other wireless applications. Implemented results are then compared with the base paper and hence good agreement is achieved between the implemented results and base paper results.

LIST OF ABBREVIATIONS

DGS……………………………………………………Defected Ground structure

VSWR…………………………………………………Voltage standing Wave Ratio

HFSS……………………………………..............High Frequency Simulation Software

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CHAPTER 1

INTRODUCTION

Communication is a way to exchanging information between two person or between two devices or between person and device. It is a way of transferring information or data. Communication between any two people living in any part of the world is only possible with the help of the emerging technology in day today life. In day to day life electronic devices is manufactured at very faster rate in order to meet the needs of people to communicate with each other irrespective of their locations. If we see today every device or every communicating media consists of an antenna which is used to transmit or receive the signals. So antenna is an important source to communicate so that information can be easily transmitted and received. Whether we are talking about wired communication or wireless, land to land or land to space, antenna plays a vital role for transferring information or data. Satellite which transmit information from the large distances consist of the antenna. It is only by the help of antenna we can receive or transmit information from these satellites. Mobile phones which are the need of the hour consists of an antenna by which the communication is possible. Other devices in which antenna plays a significant role are wireless communication, Radars, GPS devices, WIMAX, MIMO, laptops, transceivers, space vehicle navigation, airplanes and many other devices.

Fig. 1.1 Antenna

1.1DEFINITION OF ANTENNA

An antenna is defined by Webster's Dictionary as "a usually metallic device (as a rod or wire) for radiating or receiving radio waves." The IEEE Standard Definitions of Terms for Antennas defines the antenna or aerial as "a means for radiating or receiving radio waves." It acts as a transition device between free space and waveguide. In other words the antenna is the transitional structure between free-space and a guiding device, as shown in Figure 1.2. The guiding device or transmission line may take the form of a coaxial line or a hollow pipe (waveguide), and it is used to transport electromagnetic energy from the transmitting source to the antenna, or from the antenna to the receiver..

There are the different kinds of antennas present today such as Wire antennas, Aperture antennas, Array antennas, Reflector antennas, Lens antennas, Horn antennas, Microstrip antennas and many more antennas but out of them the most important antenna which is used in day today life is the microstrip antenna.

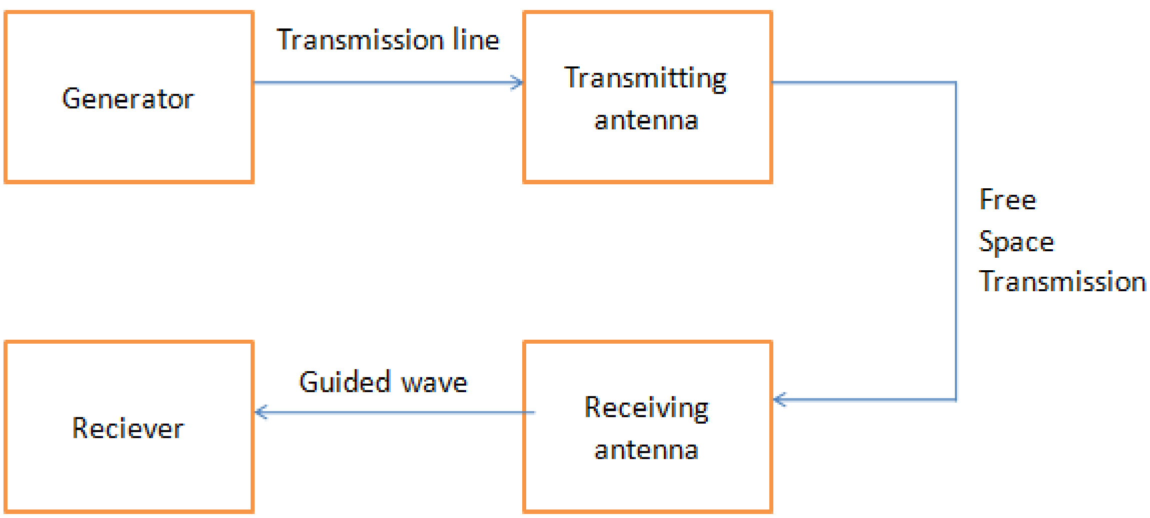


Fig. 1.2 Antenna as a transition device

1.2 TYPES OF ANTENNA

Antenna is categorized into different types depending on their characteristics and their usage. The following are the various types of antenna:

1.2.1 Wire Antenna

This is the most common type of antenna found almost everywhere in our day to day life ranging from the most common devices like mobile phones, automobiles to sophisticated devices like aircraft, spacecraft etc. Wire antenna's can vary in shape. These can be helical, circular, rectangular, straight wire or loop shaped. Most of the times circular shape of antenna is preferred due to its easy construction [1].

1.2.2 Aperture Antenna

Since with the advancements of technology there is demand for more sophisticated antenna's with high frequency utilization, aperture antenna's have gained a high importance. These antennas are widely used in applications related to aircraft and spacecraft due to their ability to be easily flush mounted onto the surfaces of aircraft or spacecraft. These can easily be protected from undesirable environmental conditions by coating them with dielectric material.

1.2.3 Microstrip Antenna

Microstrip antenna consist a patch of metal on a grounded substrate. The metallic patch of circular and rectangular configuration is most common. These antenna provide certain characteristics like low profile, inexpensive fabrication, robustness and exhibit versatility in terms of polarization, impedance and resonant frequency. These antennas find great importance in aircraft, spacecraft for providing high performance. Microstrip patch antennas are low profile, low weight antennas, easy to manufacture. Due to their light weight and low manufacturing cost, PCB based design they become attractive. They are widely used in the antenna arrays due to direct integration with the microwave circuitry. Microstrip antennas are widely used and appropriate for the military and commercial devices, such as use on aircraft or space antennas because they yield a wide variety of patterns and polarizations, depending on the mode excited and the specific shape of the radiating element used. Due to their advantages of low back radiation, ease of conformity and high gain they are in increasing demand for wireless communications as compared to the wire antennas [1].

1.2.4 Array Antenna

Since single element in antenna is unable to achieve the desired radiation characteristics, so number of elements are arranged electrically or geometrically to attain the required radiation characteristics. This is known as array antenna. Elements in an array are arranged in such a manner that each elements radiation either combine to give maximum radiation in particular direction or oppose each other to suppress the radiation in particular direction.

1.2.5 Reflector Antenna

As there were advances made in the technology and communication devices were driving importance, sophisticated antennas were required for long distance communication in order to communicate over longer distances in miles. These are referred to as parabolic reflector antenna. Since large distance needs to be covered so there is need of large diameter of about 305m. This leads to increase in dimensions of the antenna which are in turn needed for high gain for longer distance communication.

1.2.6 Lens Antenna

Basic purpose of a lens is to prevent the incident energy from spreading into undesired directions and focusing it into a narrow beam. This concept is used in Lens Antenna, where by adjusting the geometry and choosing a proper material of lens, incident energy can be converted into plane waves. These antenna's are used mainly for high frequencies as at low frequencies they acquire large dimensions and weight.

1.3 PARAMETERS OF ANTENNA

It is necessary to know certain characteristics of antenna to determine the performance of antenna in order to be used for any specific application. These characteristics can either be related to each other or independent

1.3.1 RADIATION PATTERN

Directivity, power flux density, polarization are some of the radiation properties of antenna. The graphical or mathematical representation as a function of space coordinates of the radiation properties of antenna is referred to as Radiation pattern. This can be represented in 2-D or 3-D. Radiation can either be amplitude field pattern which plots the electric field at constant radius or it can be amplitude power pattern where power density's variation with respect to radius is spatially represented.

1.3.1a Radiation Pattern Lobes

A radiation lobe is defined as a part of radiation pattern of antenna which is bounded by regions of relatively weak radiation intensity. These are classified into four parts:

Major lobe*:* It is the lobe which specifies the direction where radiation is maximum.

Minor lobe*:* The lobe is considered to be minor if it occupies any part except for the major lobe. These produces radiation in directions where radiation is not desired.

Side lobe: It is a lobe which radiates in any direction except the main lobe.

Back lobe*:* This is lobe which makes 180 degree angle with the main beam of antenna. It is kind of minor lobe which is opposite to the major lobe.

Side lobe level is defined as the ratio of power density in minor lobe to that of major lobe. It must be low for some applications like radar to avoid false indications of target by minimizing side lobe level. Less side lobe level results in radiation to be maximum at major lobe thereby increasing the directivity of antenna.

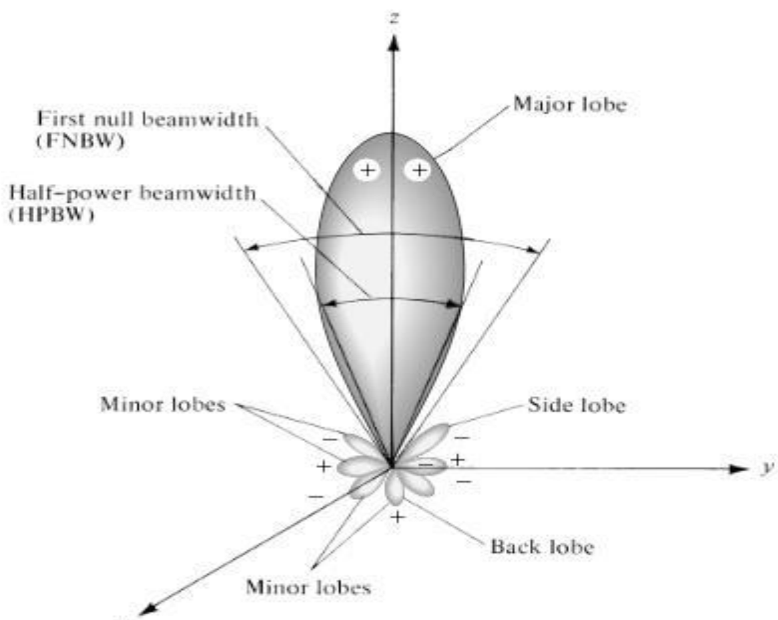


Fig. 1.3 Radiation lobes[1]

1.3.1b Field Regions

EM waves exhibit different characteristics when generated by an antenna depending on the distance from antenna [1]. So the area around the antenna is divided into different zones in order to differentiate the properties exhibited by EM waves in different regions.

Reactive near field: In this region, electric and magnetic field are out of phase. This region is nearest to antenna and surrounds it and is reactive in nature. Electromagnetic energy is completely stored here.

$$R_1 = 0.62\left(\frac{D^3}{\lambda}\right)^{1/2}$$

Radiating near field (Fresnel)*:* This region lies between the reactive near field and far field. With the increase in distance from antenna, electromagnetic field becomes less reactive, that is, some part of EM energy gets converted into radiation. The shape of radiation may vary with distance from antenna.

$$R_{2=\frac{2D^2}{\lambda}}$$

Far field (Fraunhofer) region*:* With further increase in distance from antenna EM field becomes completely radiative and there is negligible reactive field. Unlike Fresnel field, shape of radiation does not vary with distance. In this case electric and magnet field are in phase as well as orthogonal to each other.

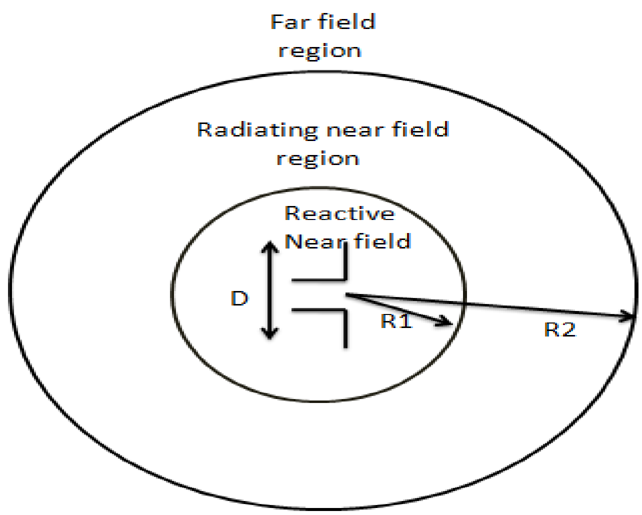


Fig. 1.4 Field regions

1.3.1c Radiation intensity

Electromagnetic power is generated by EM waves. This radiated power has variable magnitude which depends upon the distance from antenna and observation's direction. Therefore a normalized power density is required which is independent of distance from antenna in far field. This is referred to as radiation intensity.

$$U = r^2 Wrad$$

It can also be defined as power radiated by an antenna per unit solid angle. It denotes a far field parameter. It is given by the equation:

$$P_{rad} = \iint_0^{\pi} U \, Sin\, \theta d\theta d\phi$$

$$= \int Uo d\omega$$

$$= Uo \iint d\omega = 4\pi Uo$$

1.3.2 BEAMWIDTH

The beamwidth of a radiation pattern is defined as angular separation between the same points on opposite side of pattern maximum[1]. It is an important parameter which follows inverse relation with the side lobe, that is, with increase in beamwidth, side lobes decreases. The important beamwidths are:

Half power beamwidth (HPBW): It is defined as the angular separation between two opposite points in the direction of maximum beam where radiation intensity is one half the value of the beam.

First Null Beamwidth (FNBW): It is defined as the angle between the first nulls of radiation pattern. The relation between the two beamwidths can given by the equation:

$$HPBW = \frac{FNBW}{2}$$

1.3.3 DIRECTIVITY

Directivity of antenna is defined as the ratio of radiation intensity in given direction to averaging of radiation intensity over all the directions. Its mathematical expression can be given as:

Directivity = $\frac{4\pi U}{P_{rad}}$

p_{rad} = total radiated power (W)

1.3.4 EFFICIENCY

Efficiency related power delivered to antenna and radiated power. High value of efficiency mean large amount of power is radiated away and low value of efficiency mean less amount power is radiated because most of the power absorbed within in antenna as losses as a result of impedance mismatching.

Efficiency = $\frac{p_{rad}}{p_{in}}$

1.3.5 POLARIZATION

Polarization defines the orientation of electric field that is time varying direction and magnitude. It is of three type linear polarization, circular polarization and elliptical polarization.

Linear polarization: In linear polarization, the magnitude of two waves are same and phase difference is equal to zero.

Circular polarization: In Circular polarization, the magnitude of two waves are same but phase difference is equal to 90°.

Elliptical polarization: In Elliptical polarization, the magnitude of two waves are also different and phase difference is equal to 90°.

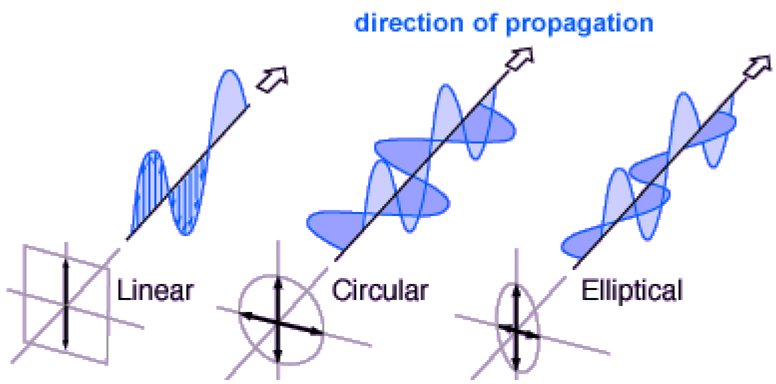


Fig. 1.5 Types of polarization

1.3.6 GAIN

Gain of antenna is defined as ratio of intensity in a given direction to radiation intensity that is attained when power accepted by antenna were radiated isotropically. Gain is expressed as:

$$\text{Gain} = 4\pi \frac{U(\theta,\phi)}{p_{in}(lossless \quad isotropic \quad source)} \qquad \text{(dimensionless)}$$

U = radiation intensity, p_{in} = total input power (W), θ = elevation angle, ϕ = azimuth angle

1.3.7 INPUT IMPEDANCE

The input impedance of an antenna is defined as the ratio of the voltage to the current at the terminals .Hence the impedance of the radiating elements can be written as given below.

$$Z_{in} = R_{in} + jX_{in}$$

Z_{in} = antenna impedance, R_{in} = antenna resistance

X_{in} = antenna reactance represents power stored in antenna

R_{in} is the resistance have two part radiation resistance and loss resistance.

Power radiated by antenna is associated with radiation resistance and power loss by antenna is related to loss resistance. For an antenna to be efficient the impedance of antenna and transmission line should be equal and standard value is 50Ω.

1.3.8 RETURN LOSS

It is the parameter of antenna which is defines the radiation characteristic of antenna. It is the ratio of power radiated to the power incident. It describes how much power is dissipated because of load. This parameter shows matching characteristic of antenna. Graph between S11 and frequency is return loss and graph should show dip at operating frequency that its value should be highly negative which show antenna radiate good amount of power deliver to it by source and very less power is lost.

$$RL\ (dB) = 10\log_{10}\frac{P_r}{P_i}$$

Where,

P_r = reflected power,

P_i = incident power

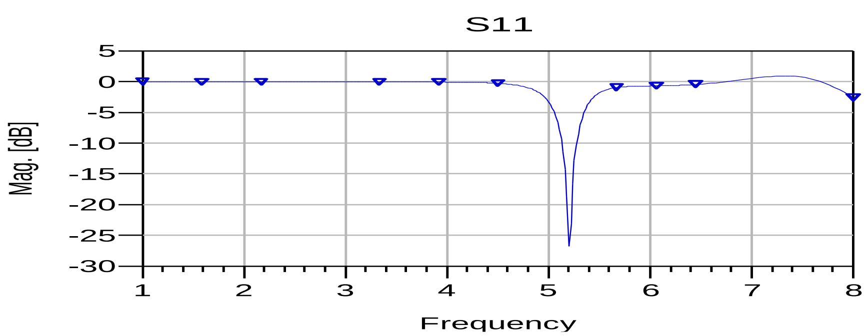


Fig. 1.6 Return loss

1.3.9 VSWR

VSWR stands for Voltage Standing Wave Ratio which is the measure of total power reflected. VSWR should be as low as possible which means that almost all the incident power is delivered to antenna and there is no reflections or standing waves created

1.3.10 S PARAMETERS

For microwave frequencies, the waves are associated to power other than voltage and current and microwave junctions are identify by S-parameters or scattering parameters. If input is apply to all the ports, 16 combinations in the form matrix are obtained. It provides relation between power of different ports in a microwave junction, through matrix known as scattering co-efficient or S-parameters

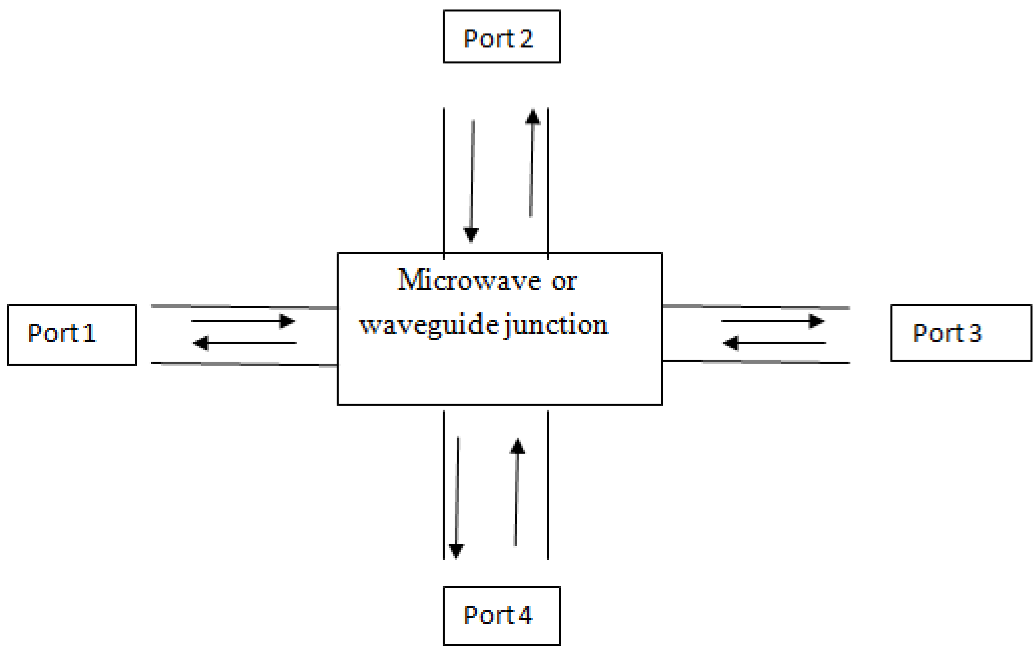


Figure 1.7 Microwave junction

1.4 SATELLITE COMMUNICATION

In satellite communication, signal transferring between the sender and receiver is done with the help of satellite. In this process, the signal which is basically a beam of modulated microwaves is sent towards the satellite. Then the satellite amplifies the signal and sent it back to the receiver's antenna present on the earth's surface. So, all the signal transferring is happening in space. Thus this type of communication is known as space communication. For satellite communication, various antennas are used such as Parabolic Reflectors, phase arrays, microstrip antennas, etc [7].

For better performance of the satellites communications one has to improve two aspects keys in the systems of communications: the quality of the service (greater quality and bandwidth of the signal) as well as the costs (smaller investment for the operation and maintenance), during the process of improvement of these two aspects one of the ways concludes that to obtain it is to miniaturize the communications components, this results in discovery of the technology microstrip [6]. The dimensions of the microstrip antennas are chosen so that the structure dissipates the power in the form of radiation. With the development of the satellite technologies and its consequent miniaturization, appeared the antennas microstrip, giving the possibility of reducing costs, size, and of maintaining or of improving the quality of the satellite links and terrestrial. With low cost and size, it was possible to carry out the satellite technology to more people around the world, to communicate between each human.

Some basic characteristics to take in consideration on microstrip antenna are: Polarization, Antenna shape, Arrays Antennas, Bandwidth and so on. Dual polarization is used on a communications satellite for the reusability of the frequencies, to cover two different coverage areas with same frequency but with different polarization, this can be carried out using 2 transponders system, each one for each polarization, and these can be RHCP or LHCP. In satellite Communications circularly polarized radiation patterns are required using an either a rectangular or circular patch. A parabolic reflector antenna is generally employed for receiving direct broadcast from a satellite. This antenna required a large area for installation, and can be replaced by a flat antenna (Array Antenna) in the form of microstrip array. This antenna is the equivalent to parabolic reflector. A phased-array antenna has a number of advantages over a lens or reflector antenna, as see in [7]. This is due to the distribution of power amplification at the elementary radiation level, higher aperture efficiency, no spillover loss, no aperture (feed) blockage, and better reliability. Rectangular Patch Antenna, because was the first geometry to be investigated, the second one is Circular and Annular Patch, the last one is Triangular Patch Antenna or other shapes. The two firsts offer better performance than the last one or other shapes used in the common applications on Satellite Communications. One of most important requirement is the gain, and for this use a annular ring and apply the microstrip technology to feed the antenna to achieve the required gain.

1.4.1 APPLICATIONS OF SATELLITES

Space technology has advanced rapidly in recent years. Satellite plays an important role in daily life. Here are few important satellite technology applications as shown in Figure1.1

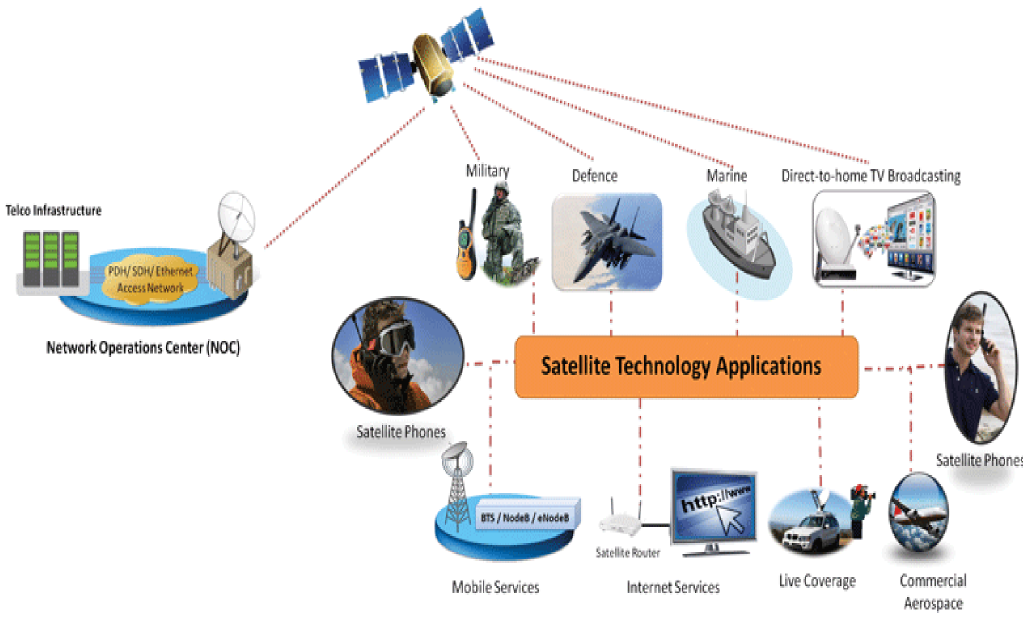


Figure 1.8 satellite technology applications

People use all these satellite applications in day to day life and making use to satellite antenna in many of applications. These satellite antenna works on different frequency bands like for defence X band of satellite is required and NASA Scientists use to work on S band (2 to 4 GHz) Other Applications of Satellite communication as listed below

- Weather
- Radio and TV Broadcast
- Military Satellites
- Navigation Satellites
- Global Telephone
- Connecting Remote Areas
- Global Mobile Communication

1.4.2 FREQUENCY BANDS USED FOR SATELLITE

Allocation of frequencies to satellite services s a complicated process which requires international coordination and planning. This is done as per the International Telecommunication Union (ITU). To implement this frequency planning, the world is divided into three regions:

Region1: Europe, Africa and Mongolia

Region 2: North and South America and Greenland

Region 3: Asia (excluding region 1 areas), Australia and south-west Pacific.

Below are the frequencies allocated to these satellites:

S.No	**Band**	**Frequency (GHz)**
1	VHF	0.1-0.3
2	UHF	0.3-1.0
3	L	1-2
4	S	2-4
5	C	4-8
6	X	8-12
7	Ku	12-18(Ku is under K band)
8	Ka	18-27(Ka is above K Band)
9	V	40-75

Table1. frequency bands for satellite communication

.

Within these regions, he frequency bands are allocated to various satellite services. Some of them are listed below.

- *Fixed satellite service*: Provides Links for existing Telephone Networks Used for transmitting television signals to cable companies
- *Broadcasting satellite service*: Provides Direct Broadcast to homes. E.g. Live Cricket matches etc
- *Mobile satellite services*: This includes services for: Land Mobile, Maritime Mobile, Aeronautical mobile
- *Navigational satellite services* : Include Global Positioning systems
- *Meteorological satellite services*: They are often used to perform Search and Rescue service

1.4.3 SATELLITE ANTENNA TYPES

1. Parabolic Antenna

2. Horn Antenna

3. Phased Array

4. Helical Antenna

5. Microstrip Antenna

All above antennas are used in satellite applications depending upon the operating frequency of Band. Most of the research by NASA these days is focused on S and C Band applications and the satellites which works on these frequency bands are Cubesat and nanoSat.

1.5 SCOPE OF STUDY

Microstrip Patch Antenna is widely used in nowadays communication system. As wireless communication is the need of the hour and requires the antenna which can cover wide range of application. All these requirements can be fulfill by microstrip antennas as they are providing various features low profile, low-cost, compact size and wideband system designs. Single antenna is sufficient to provide access to wide applications by using microstrip antenna.

Microstrip antenna have many advantages as discussed earlier, so it fits well for all application. Past year's study have shown that most of the work in antenna emphasized on making of compact size antenna and better efficiency. Many techniques and designs have been proposed to build compact size antennas to make it more reliable by reducing patch size or reducing thickness of substrate so that antenna can be easily used in various devices by occupying little space

Microstrip antennas are possessing all these features of compact size low cost and low profile antenna so these antenna are fulfilling the requirement of devices used in today's era. Though there are some limitations such as limited bandwidth but many techniques have been developed to eliminate this limitation so that microstrip antenna can provide sufficient bandwidth for working of various application. Many techniques and designs have been proposed to build compact size antennas to make it more reliable by reducing patch size or reducing thickness of substrate so that antenna can be easily used in various devices by occupying little space.

Satellite communication also required compact size antenna as they can be easily installed in Nanosatellites, picosatellite. For high gain in satellite communication , an array of patch antenna is used rather than a single antenna which provides more gain than a single patch antenna. It can be easily manufacture as it includes two dimensional geometry. It supports both linear and circular polarization. These are efficient radiators. To generate multiple beam, we require several antennas but they take a lot of space on the satellite which is small, so by using array of microstrip antennas, multiple beams can be generated results in compactness.

CHAPTER 2

LITERATURE SURVEY

Akio kuranoto et al. in 1988 describes mechanically steered tracking antenna for land mobile communication [9]. Antenna for vehicle is key requirement so that communication is maintained when vehicle is moving in beam coverage area. This antenna system consists of 8 element printed spiral antenna array, here concept of single channel tracking controller and antenna driven mechanism that is motor is used. The beam direction can be changed by switching or by phase shifting of PIN diode . This mechanically steered antenna for land communication is designed for tracking satellite.This type of antenna is bulky and has high power consumption because of use of the electric motors responsible for the mechanical steering. An alternative solution is a planar phased array antenna which performs beam steering by electronic means.

M.E. Bialkowski et al. in 1996 describes an L-band electronically steered antenna for land vehicle mobile satellite-communications system which is designed for the Australian continent [10]. A 14-element cylindrical antenna array for use at the vehicle end. The array uses electronic steering to maintain a communications channel to the satellite. Here phased array antenna performs beam steering by electronic means. The power beam is steered by switching the RF power system. The algorithm for the satellite-tracking system is based on a combination of closed- and open-loop tracking for improved tracking performance and reliability. The developed algorithms were able to recover the satellite's direction even in those cases when the car was making a turn and at the same time the signal was shadowed by a tree or a building. The overall design of the system has been very cost effective due to the low cost of the antenna elements and switching system as well as inexpensive tracking electronics. The measured return loss over a 1.6GHz bandwidth is better than l0dB.

Usha Kiran K. et al. in 2006 describes novel compact broadband dual frequency microstrip antenna [11]. The proposed design consists of a rectangular microstrip antenna and close to the radiating edge of the patch pair of parallel slots are loaded and in antenna's ground plane three meandering narrow slots are embedded. By varying length of meandering slots, various results has been calculated. By using three meandering slots in the ground plane, resonant frequencies get lowered significantly with enhancement of operational bandwidth in comparison to standard rectangular microstrip antenna without slots. By introducing slots in the design, the proposed antenna has size reduction of 50.6% and 30% for two resonant frequency and bandwidth enhancement of 12.2% and 4.5% as compared to standard rectangular antenna without slots. So, by this approach, compact size antenna with bandwidth enhanced has achieved.

Abdelaziz A. Abdelaziz et al. in 2007 describes the technique for reduction of size of antenna [12]. Here shorting wall length technique is used to design compact size antenna which is applicable for GPS communication. Here by reducing shorting wall length, it has been seen that resonance frequency also get reduced ,so for keeping the resonsance frequency(1.575) same, the length of patch get reduced. As the patch length reduces the axial ratio of antenna also get degrade. To compensate this, we adjust the perturbation segment length ΔL .By this axial ratio get improved. As patch length is reduced for keeping the resonance frequency same so it results in reduction of size of antenna which is the need of the hour for nowadays required devices. In this paper, the size reduction of 24.6 % is there as compared to conventional rectangular microstrip patch antenna.

Ghulam Ahmed et al. in 2009 presented a paper to provide the overview of antenna design. It provides different pararmeters which can effect the antenna design [8]. the papers reveals about various satellite orbits, polarization selection, antenna design drivers, space environment, satellite antenna coverage, softwares of antenna, contour beam implementation, satellite antenna analysis techniques, satellite antenna design tools, satellite antenna tests, remotely configurable satellite antenna. This papere provides us various consideration in designing of antenna which can effect the performance.

Navdeep kaur et al. in 2010 describes a coxial feed Microstrip Patch Antenna operating at 4.6 GHz frequency, having four L shaped slots is presented [13]. Here conventional antenna is compared with slotted patch antenna and it has been seen that there is decrease in size and and bandwidth has also increased. Further when ground plane is also introduced with some defects and it has been seen that it yields more better result than full ground plane as well as conventional antenna. Antenna with full Ground Plane has return loss -17.91dB and gain 7.9dB is achieved but by defecting the Ground Plane return loss and gain further improved to -21.23dB and 8.4dB.The performance parameter is simulated using software HFSS. Here coxial feeding is used to reduce spurious radiation and for better matching of Impedence. The proposed antenna with full ground has bandwidth 222 MHz and the antenna with defected ground plane has bandwidth enhanced to 312 MHz. The proposed microstrip Patch antenna has compact size designed for C band downlink frequency in satellite communication applications.

T. K. Sreeja et al. in 2012 proposed an antenna for Nanosatellite application [14]. The aim to design an antenna with low weight, low profile with better gain and directivity. The antenna consists of low profile, low weight patch antenna with 2 antenna elements of physical dimension 37*27*1.25mm^3. Each elements have 2 slots of U shaped and other of rectangular shape. U-shaped slot for providing dual band application. This antenna provides better gain and directivity.

M. Samsuzzaman et al. in 2013 describes antenna with dual band, triple frequency X shaped patch [15]. The proposed antenna in this paper is designed with five rectangular slots which produces dual band operation for KU band and single for K band application. This antenna gives desired results for KU/K band application and results in omni-directional and stable radiation pattern with low cross polarization. This antenna is best suited for satellite communication, Aircraft collision avoidance system.

Pristin K Mathew et al. in 2014 describes wideband triple frequency microstrip patch antenna for wireless and communication is designed to construct compact and reduced size antenna [16]. Here reduction in size is done by introducing slits in non radiating edge of the patch. The proposed antenna consists of array of slits that enable to operate at ISM, WIMAX and Satellite communication. In this design, six rectangular slits are etched and a pair of wider slits which results in reduction of size, bandwidth enhancement. The feeding technique used is coxial probe feeding. The patch is meandered by cutting six slits for dual band operation and a pair of slit for satellite communication. The proposed antenna is simulated using software CADFEKO and parameters such as bandwidth, return loss and VSWR is measured.. In comparison to conventional microstrip patch antenna, the proposed antenna achieves more than 80% reduction in size and reduction in resonant frequency by 45%. This antenna is well suited for wireless communication system.

Sudeep Baudha et al. in 2014 describes an antenna with truncated corner broadband patch and circular slost [17]. Due to circular slots and truncated corners, bandwidth enhancement and best impedence matching has taken place. Due to circular slots, the antenna starts resonating at lower frequencies and by corner truncating, the antenna starts resonating at higher frequencies, so combine results in bandwidth enhancement. Band width enhancement of 123% as compared simple patch has been seen here. This antenna supports the application such as satellite application, RADAR communication

M. T. Islam et al. in 2014 proposed a circularly polarized compact microstrip antenna with low axial ratio for small satellite [18]. The design based on V- shaped slits and parasitic element introduced in patch. V-shaped slits are for circular polarization and rectangular strip is for wide axial ratio bandwidth. The antenna is designed for satellite named HORYU-IV and by taking in consideration the requirements of this satellite, antenna is designed. Simulated and measured 10-dB return loss bandwidth are 2.74 % (2.2527- 2.3152 GHz) and 2.73% (2.2450-2.3075 GHz), respectively. The measured 3-dB AR bandwidth is 17 MHz and simulated bandwidth is also near about 13 MHz. The maximum gain is 7.29 dBi at 2.285 GHz. The overall dimension of the antenna is $0.61\lambda\times0.61\lambda\times0.01\lambda$ at 2.285 GHz.

M. T. Islam et al. in 2015 proposed a compact single layer coxial- probe- fed high gain patch antenna for HORYU-IV nanosatellite S-band communication [18]. The overall dimensions of the antenna are $0.61\lambda\times0.61\lambda\times0.01\lambda$ at 2.285 GHz with the weight of 25 g. The simulated 3-dB AR bandwidth is 0.56% (2.293–2.280 GHz), which is slightly less than the measured bandwidth of 0.74% (2.278–2.295 GHz). The impedance and AR bandwidth are sufficient to cover the HORYU-IV S-band communication requirement. the antenna exhibits an effective bandwidth of 2.73% from 2.2450 to 2.3075 GHz, for 10-dB return loss. The measured gain of the antenna prototype is around 7.29 dBi, and the 3-dB AR beamwidth is about 1560 at 2.285 GHz.

B.Azim et al. in 2015 designed a circularly polarized antenna for s-band satellite communication system [19].Here antenna consists of rectangular patch and full ground plane. In this design two rectangular slots get etched from the patch so that size can be compact and for achieving circular polarization. This antenna results in 3dB AR Bandwidth of 30 MHz with -10dB reflection coefficient. This antenna can prove better for wireless application.

Pravin Ratilal Prajapati et al. in 2015 describes a compact circularly polarized (CP) microstrip antenna for mobile satellite communication band of India (1.492– 1.518 GHz) is designed [20]. Two asymmetric length rectangular shape slots, perpendicular to each other are printed on the circular patch so that circular polarization can be achieved. In order to improve the performance parameters of patch antenna such as axial ratio (AR) bandwidth, return loss bandwidth, radiation efficiency and many more a new technique of combination of fractal theory and defected ground structure (DGS) is used. Defected ground structure (DGS) concept has also been used to improve the planar antenna's desired characteristics. Size reduction in patch size results as 44.74%, enhancements of 62.73% in AR bandwidth, 70.74% in return loss bandwidth and 4.03% in radiation efficiency is extracted as compared with conventional patch antenna, after incorporating fractal DGS in the ground plane. In this, the use of fractal DGS in the design results in better results than traditional antenna without DGS. Performance enhancement is been seen in terms of compact radiating patch, better radiation efficiency, optimum gain, optimum return loss bandwidth and AR bandwidth.

Yuktitath Chawanonphithaka et al. in 2016 proposed a miniaturized dual band V- shaped monopole antenna fed by V- stub. Substrate used is Fr4. The total size of antenna is 18*26*1.6 mm^3. The antenna composed of V- shaped stubs. This antenna is applicable for WIMAX and WLAN applications [21]. It is low profile, low cost antenna. The achieved gains of antenna at 3.5 GHz and 5.5 GHz are 1.51 dBi and 2.34 dBi and produce omnidirectional beam. Band width achieved are 3.24 GHz - 3.71 GHz and 4.85 GHz – 5.87 GHz for less than -10 dB return loss.

Simon Mener et al. in 2016 proposed a novel Ka- band dual band dual circularly polarized antenna array for satellite communication. Left hand circular polarization for downlink frequencies and right hand circular polarization for uplink frequencies [22]. By applying sequencial rotation techjnique, the 2×2 subarray is designed for good radiation pattern and to achieve good polarization purity. This antenna is applicable for satellite communication.

Chu.Gao et al. in 2016 designed an antenna array with 12 elements which is suitable for Airborne satellite communication applications [23]. The overall size of antenna makes it well suited for airborne app alication. To generate dual circular polarization, antenna can be generated by microstrip patch and a hybrid. This antenna produces radiation pattern with low cross polarisation and results in bandwidth of 14% and measured gain of 13dbBi is achieved.

2.1 SURVEY ON MICROSTRIP ANTENNA

In applications where high performance is vital i-e where weight, cost, performance, size and ease of installation are the bounds low profile antennas may be required [2]. To meet these requirements the microstrip antennas can be used. They are low profile, economical, low weight antennas which are conformable to planer and non-planer surfaces. They are one of the useful antennas at the microwave frequencies i-e, frequencies above to 1 GHz (f > 1 GHz).

The simplest form of the microstrip antenna is shown in the Figure 3.1 and Figure 3.2 which consists of a radiating patch on one side of the dielectric substrate and a ground plane on other side.

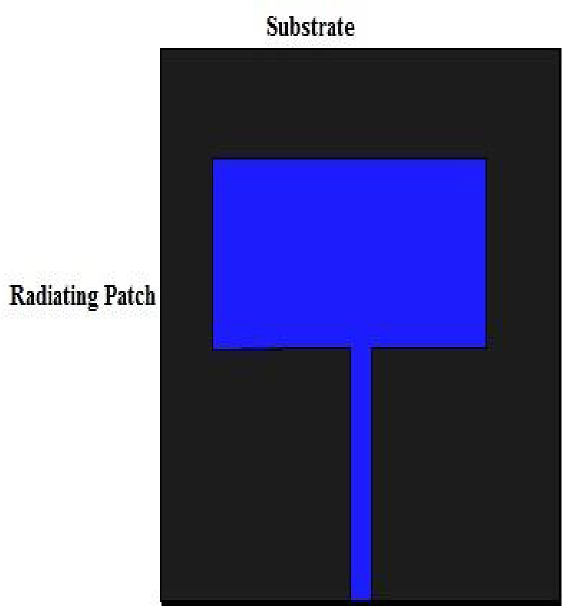


Fig. 3.1 Patch on the substrate

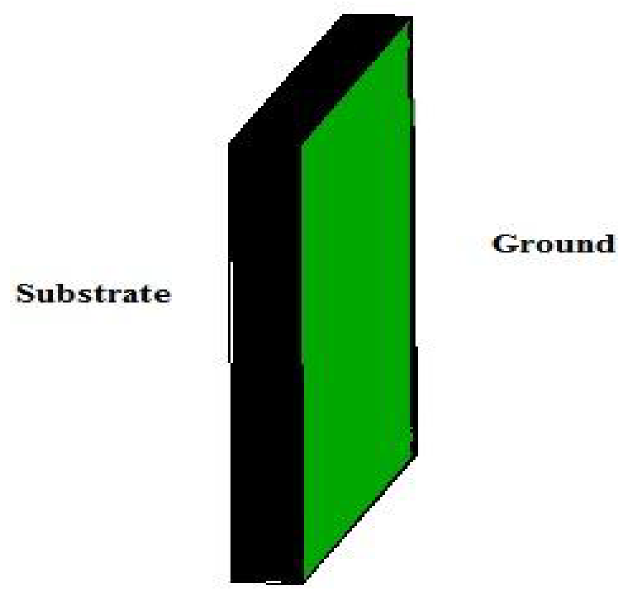


Fig. 3.2 Ground below substrate

The patch is commonly made of the gold, copper and many others i-e the materials with good conductivity and can have any shape. The radiating patch and the lines which feed antenna are commonly photo imprinted on the dielectric substrate

2.1.1 CHARACTERISTICS OF MICROSTRIP ANTENNA

Microstrip antenna consists of a metallic patch embedded on a ground plane. Designing of microstrip antenna is chosen such as it provides maximum pattern in direction normal to the patch. This can be achieved by choosing a proper method of excitation beneath the patch. Another important characteristic which must be considered during design of antenna is dielectric constant which is in the range of 2.2 to 12. Thick substrates provide better performance since they provide better efficiency, large bandwidth, radiation into space is loosely bound. But this in turn increases the size of element. So a lower valued substrate is chosen which results in small element size and tightly bounded fields in order to reduce undesired radiation and coupling but have small bandwidth and low efficiency.

2.1.2 MSA OPERATIONS

The patch acts almost as a resonant cavity, where the patch is on the top, the ground plane is on the bottom. The patch edges act as open circuit boundary condition. In the cavity some modes are allowed to exist at different resonant frequencies [1]. At resonant frequency, when the antenna is excited, a strong field is generated inside the resonant cavity and strong current on the surface of patch is produced which produces significant radiation from the fringing fields between the edges of the patch and the ground plane.

Quality factor (Q) of microstrip antenna is very large. Q represents the loses associated with an antenna. With increase in value of Q, efficiency decreases and bandwidth becomes narrow. Q can be decreased by increasing thickness of substrate which leads to increase in size of antenna. Not only this, increase in thickness of substrate leads to delivery of total power from source to surface waves. This results in unwanted power loss as all this power is scattered at bends and leads to degradation of characteristics of antenna. Now to calculate length and width of microstrip patch the following equations are used:

$$W = \frac{C}{2f_o\frac{\sqrt{\varepsilon r + 1}}{2}}$$

W= width of patch

$$\epsilon_{reff=\epsilon_r}\frac{\epsilon r+1}{2}+\frac{\epsilon r-1}{2}+\left(1+12\frac{h}{w}\right)^{1/2}$$

$\epsilon reff$=effective dielectric constant

$$Leff=\frac{c}{2f_{0\sqrt{\epsilon reff}}}$$

L_{eff}= length of patch

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

L= actual length of patch

2.1.3 ADVANTAGES

Microstrip antenna are used for various embedded devices like hand held devices like mobile phones owing to the low profile property they exhibit. Other advantages of microstrip antenna are:

- Low weight and volume
- Ease of fabrication and implementation
- Mechanically robust when mounted on rigid surfaces
- Provides polarization diversity
- Helps in easy integration with microwave integration circuits

Major advantages like high gain, ease of conformity and low back radiations made microstrip antenna to be widely used in wireless communication as compared to wire antenna.

2.1.4 DISADVANTAGES

Like the two sides of a coin, despite of providing numerous advantages, there are even some demerits which are produced by microstrip antenna. Following is the list of disadvantages due to design of microstrip antenna:

- Low gain
- Narrow bandwidth
- Presence of conduction and dielectric loses results in relatively low efficiency
- Feeds and junctions provide extra radiations

- Excitation of surface waves
- Low power handling capacity
- Feeding structure in case of arrays results in large ohmic loses
- high cross-polarization radiations

2.1.5 APPLICATIONS OF MICROSTRIP ANTENNAS

Some system applications for which microstrip antennas have been developed are:

- Satellite communication.
- Doppler and other radars.
- Radio altimeters.
- Command and control systems.
- Missiles and telemetry (stick-on sensors and weapon focusing).
- Remote sensing and environmental instrumentation.
- Satellite navigation receivers.
- Mobile radio (pagers, telephones and man-pack systems

2.2 FEEDING TECHNIQUES

Various feeding techniques are used to feed the antenna elements. It can be categorized into contacting and non-contacting methods [1]. Connecting element such as a microstrip line is used to directly feed the radiating patch with RF power in case of contacting method. In the non contacting method, process of electromagnetic coupling is used to deliver power to radiating patch of microstrip antenna. Various important feeding techniques are microstrip line, coaxial probe, aperture coupling and proximity coupling [4].

2.2.1 MICROSTRIP LINE

This is a contacting method to feed antenna element. A narrow strip is directly connected to edge radiating patch of antenna. The width of the conducting strip is small as compared to microstrip. This gives the advantage of attaining a planar structure as the strip can be etched on same surface where patch is present. The inset cut is made to match the impedance of feed line to the microstrip patch without the use of any additional matching circuit. So the position of inset cut be adjusted accordingly.

ADVANTAGES

- Planar structure.
- No additional matching circuit required so its designing is simple.
- Ease of fabrication.

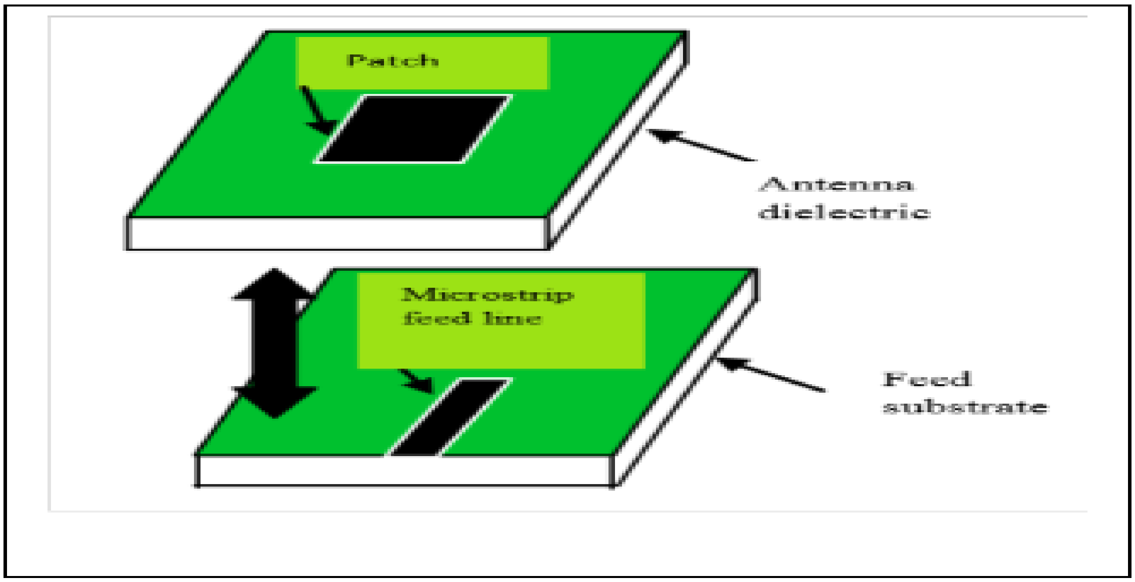


Fig. 3.4Microstrip line

DISADVANTAGE

- Increase in dielectric substrates thickness leads to increase in surface waves and spurious feed radiations.
- Feed radiations leads to increased cross polarization.
- Bandwidth is hampered due to surface waves and feed radiations

2.2.2 COAXIAL PROBE

It is a form a contacting method as power delivered is via direct connection with microstrip patch. It consists of two conductors, inner and outer conductor. Inner conductor of the coaxial connector extends through the dielectric substrate and gets connected to radiating patch. Outer conductor on the other side connects the ground plane

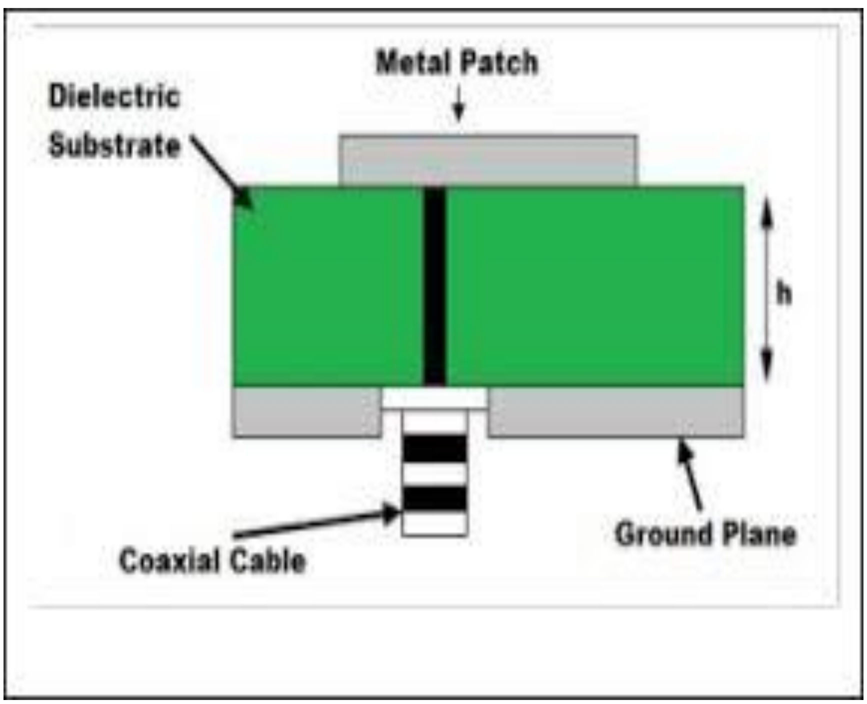
.

ADVANTAGES

- Coaxial conductor can be placed anywhere inside the microstrip patch so as to match the impedance of patch.
- Easy fabrication.
- Low spurious radiations

DISADVANTAGES

- Modeling is difficult as a hole must be drilled inside the substrate and the connector extends from the ground plane, thereby, making the structure non planar for thick substrates a narrow bandwidth.
- In case of thicker substrates, matching problem takes place due to increase in length of probe which makes input impedance more inductive.



- Fig. 3.5 coxial probe

2.2.3 PROXIMITY COUPLING

This is also known as electromagnetic coupling method and is a non contacting type. In this method, two substrates are placed one above another where feed line is between them and the upper substrates surface contain the radiating patch. Matching is obtained by controlling length of feed line and width-to-line ratio.

ADVANTAGES

- High bandwidth.
- No spurious feed radiation due to increase in thickness of microstrip patch antenna.

DISADVANTAGES

- Increase in thickness of antenna.
- Since two dielectric substrates require proper alignment, fabrication is difficult.

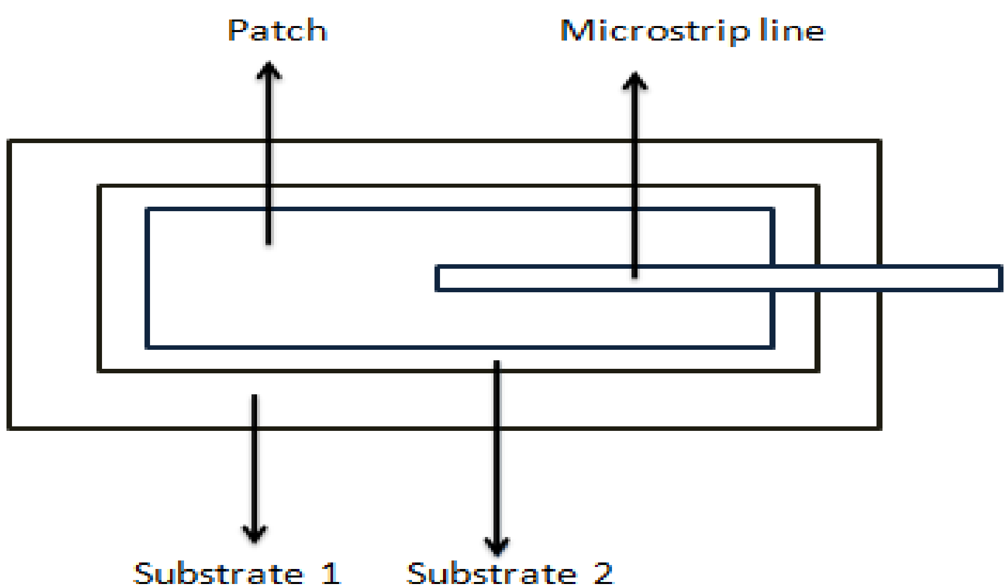


Fig. 3.6 Proximity coupling

2.2.4 APERTURE COUPLING

This is a non-contacting method of feeding which involves the usage of two substrates which are separated by ground plane. A slot or aperture is made in the ground plane in order to provide coupling between patch and feed line. Shape, size and location of aperture decide the amount of coupling between patch and the feed line. In order to get optimum radiations, low dielectric material is used for top substrate and high dielectric material is used for the bottom surface.

ADVANTAGES

- Symmetry of configuration is acquired due to presence of coupling slot under the microstrip patch which results in lower cross-polarization.
- Due to the presence of ground plane between the two substrates, spurious radiations are reduced

DISADVANTAGES

- Multiple layers lead to increase in thickness.
- Fabrication is difficult and narrow bandwidth.

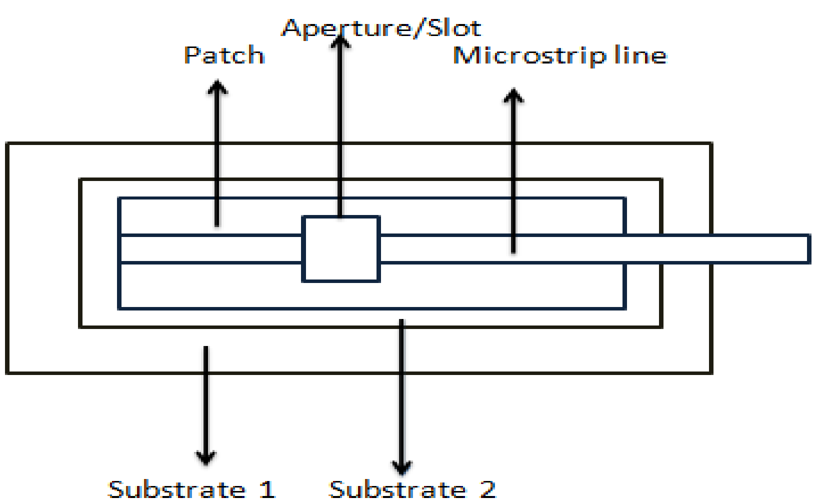


Fig. 3.7 Aperture coupling

CHAPTER 3

OBJECTIVE OF STUDY

The major contribution of the work would be as follows:

1. Comparative analysis of various designs of antenna for satellite applications.
2. Designing and optimization of the proposed antenna for different antenna parameters.
3. Fabrication, testing and validation of the proposed antenna.
4. Comparative analysis of proposed antenna design with various existing antenna of satellite application.

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CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

In this chapter, the simulation tool High Frequency Simulation Software (HFSS) which is been used for the designing and simulation of the antenna is described.

HFSS is an interactive software package for calculating the electromagnetic behavior of a structure designed by Ansy. The software includes post-processing commands for analyzing this behavior in detail.

Using HFSS, we can compute:

- Basic electromagnetic field quantities and, for open boundary problems, radiated near and far fields.
- Characteristic port impedances and propagation constants.
- Generalized S-parameters and S-parameters renormalized to specific port impedances.
- Radiation pattern and Gain in Rectangular, 2D and Polar plots.
- The Eigen modes, or resonances, of a structure.

HFSS is the industry-standard simulation tool for 3D full wave electromagnetic field simulation. HFSS provides E-Fields, H-Fields, currents, S- parameters and near and far field radiation field results. These equation systems are linear if the underlying PDE is linear, and vice-versa. Algebraic equations systems are then solved using numerical linear algebraic methods.

4.2 Procedure Overview

The procedure which is fallowed in the designing of the structures in HFSS is shown in the figure 4.1. The first step involved in the designing of the model in the HFSS is to draw the geometric model of the structure that is to be analyzed. Then the objects that are being drawn are assigned the materials of which they are made and various other properties like transparency, color etc. can also be assigned at the same time. The next step is to define the boundaries for the structure such as perfect electric or magnetic conductor. After defining the boundaries the structure is excited by the port or the voltage source which needs to be excited. Once the boundaries and excitations are defined the structure is completely modeled and the solution is set up for the structure. This solution step requires the assignment of the frequency sweep at which adaptive mess requirement takes place. After completion of the solution step the structure is simulated and after the completion of simulation the solution data is post-processed which includes the graphs for the various parameters such as S11 parameter, VSWR and far field plots.

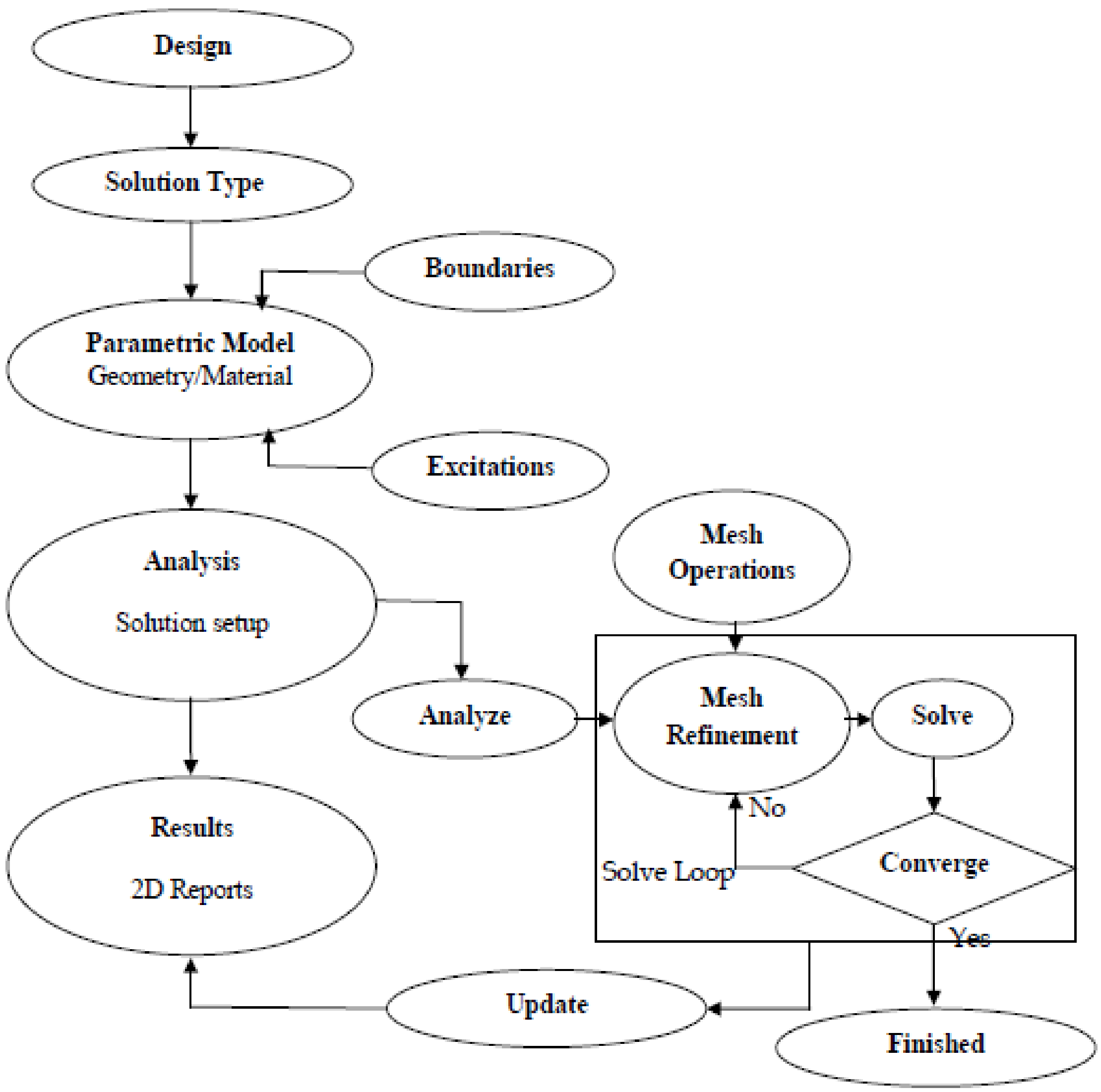

Fig. 4.1 HFSS procedure overview

Following are the step to be taken for designing of antenna in HFSS software:

Step1) The first step in designing any type of the antenna is to select the type of substrate which has appropriate thickness and loss tangent. It can be done by selecting box and providing dimensions.

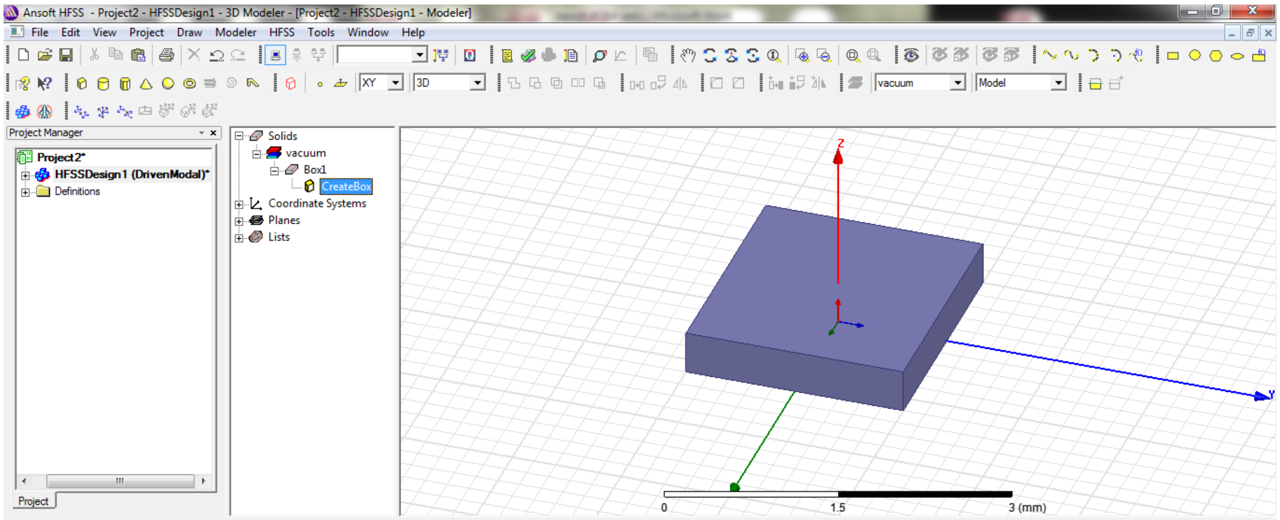

Fig. 4.2 design of substrate

Step2) Now we take rectangle for the formation of patch by providing the dimensions .

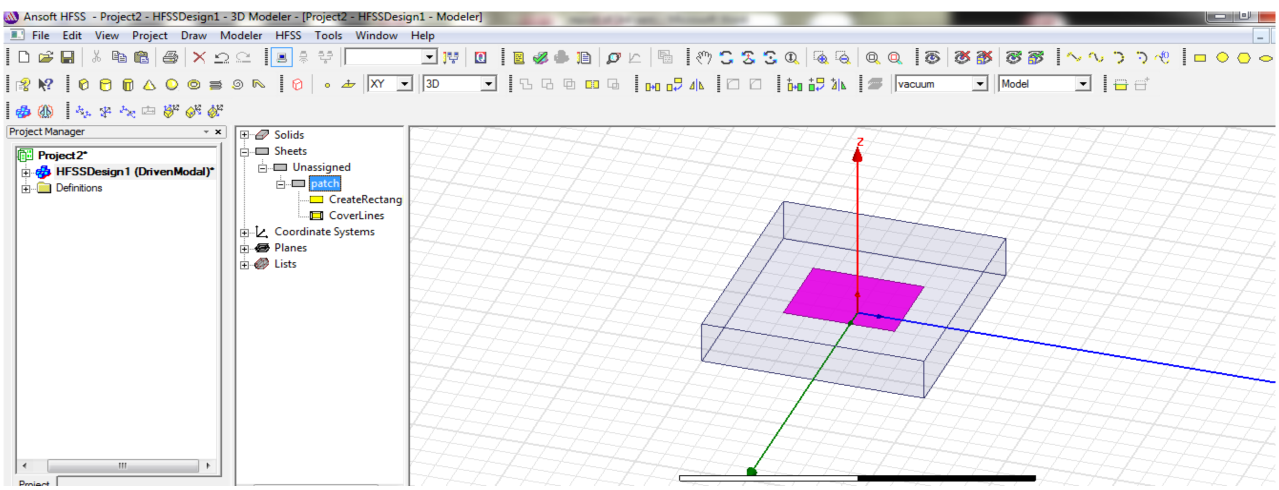

Fig. 4.3 showing patch on substrate

Step3) Now we need to form ground plane according to the dimensions required by taking rectangle from the draw option on the top HFSS window. As we can clearly see ground plane below substrate.

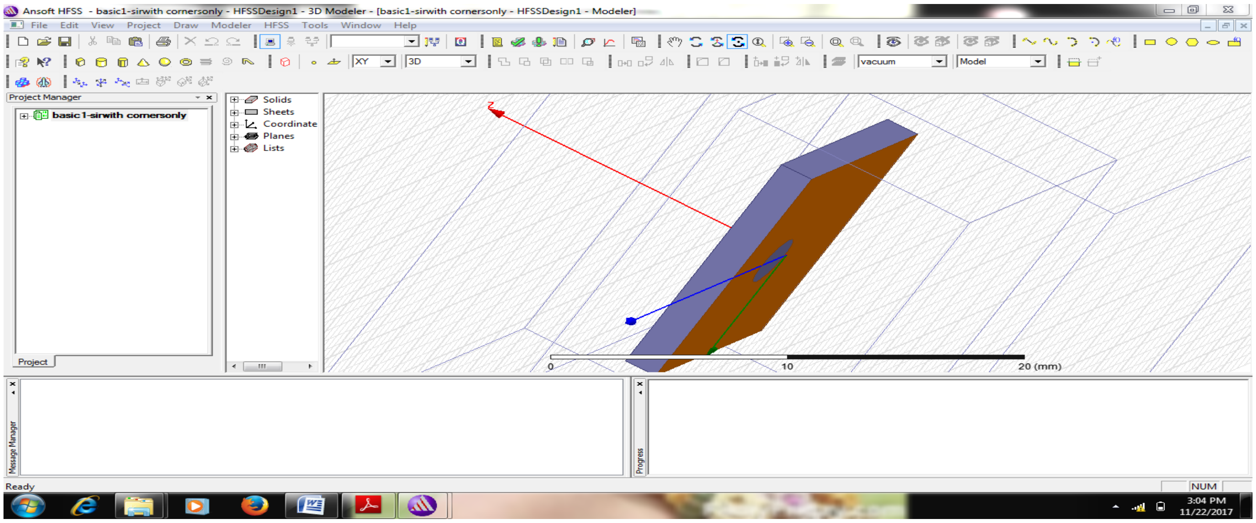

Fig. 4.4 Ground plane below substrate

Step4) now we provide coxial feeding by selecting the cylinder from draw. For coxial feeding, we take two cylinder having two radius inner and outer. For inner cylinder we take material Pec and for outer radius, material is Teflon.

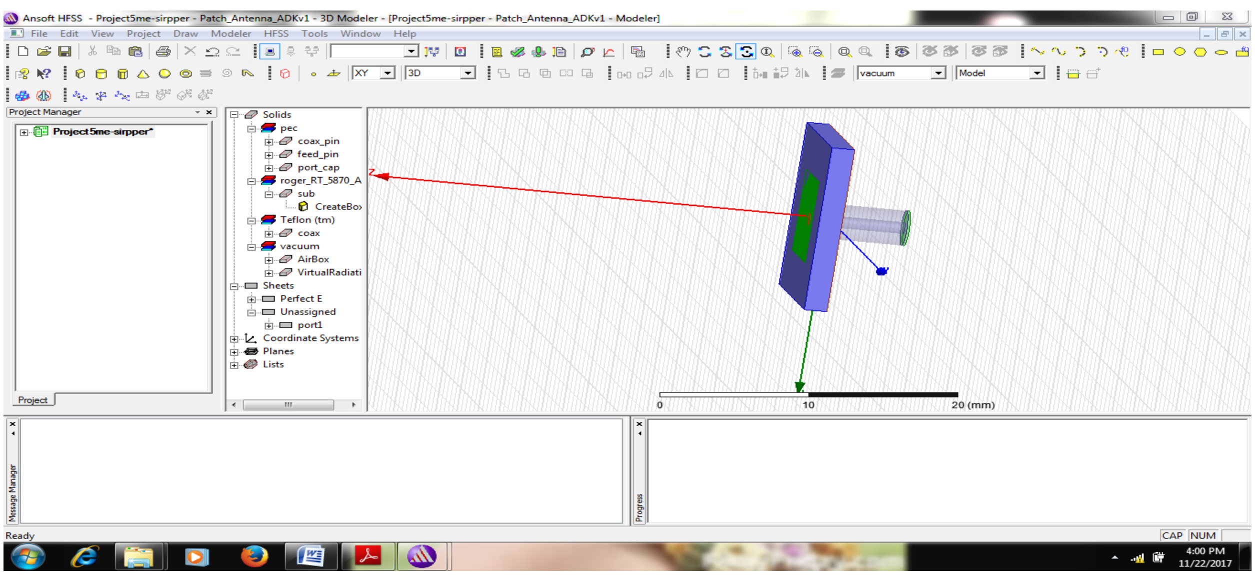

Fig. 4.5 Feeding(coxial)

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STEP 5) After feeding is done, we need to apply boundaries to patch , ground plane, outer coax and radiation box and excitation is applied to port.

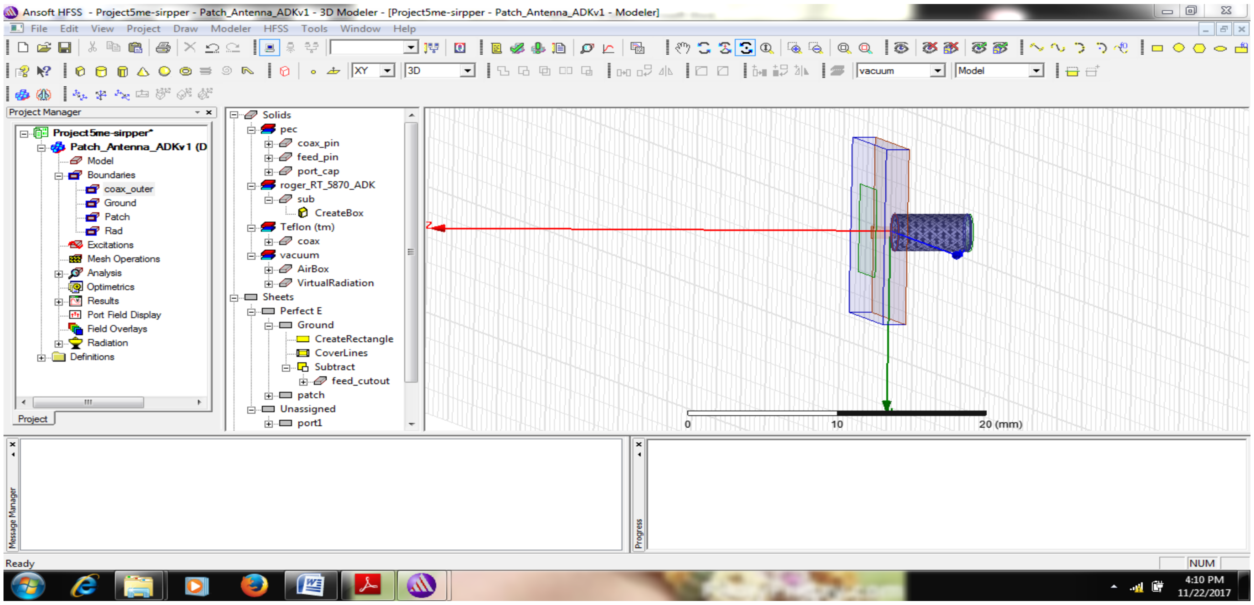

Fig. 4.6 showing assignment of boundaries and excitation

Step7) Analysis is done by adding sweep set up and assigning start and stop frequency. If whole design is complete as shown below then start simulation and check results.

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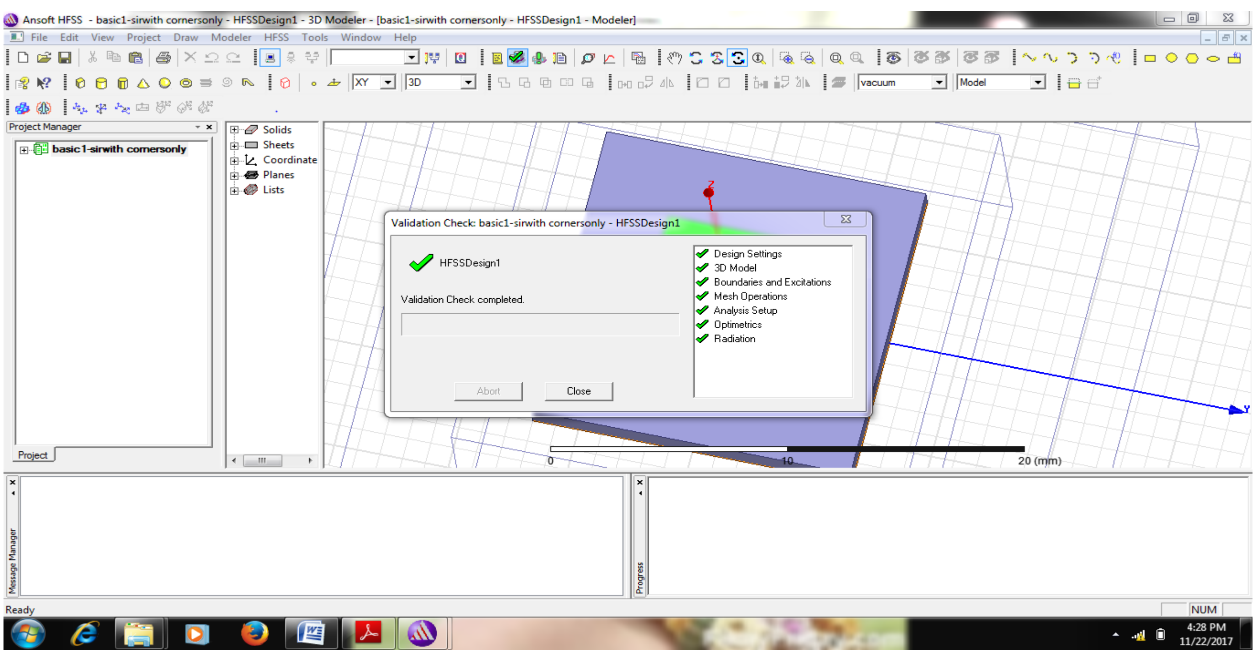

Fig. 4.7 showing completion of design

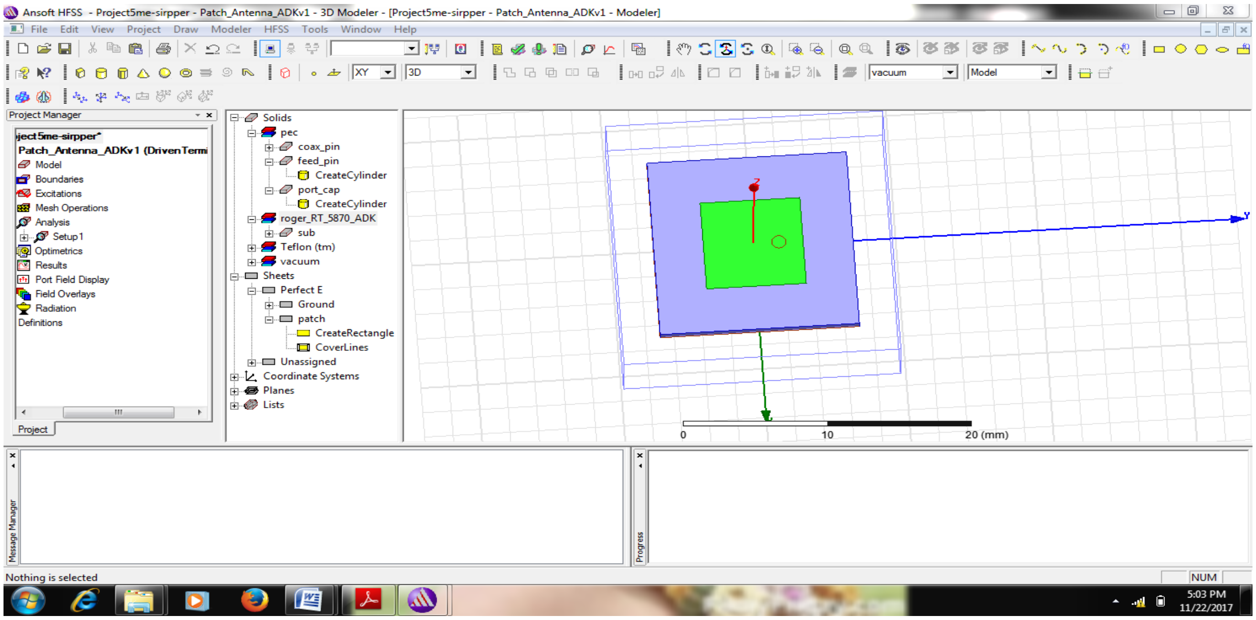

Fig. 4.8 showing complete design of basic patch antenna.

By using HFSS we can implement any type of feeding technique. The above steps are shown for coxial feeding.

CHAPTER 5

IMPLEMENTATION OF DESIGN / WORK DONE

5.1 DESIGN -1

The antenna design-1, implemented by me on software HFSS was designed by **Sudeep Baudha et .al in 2014 .** The proposed antenna is fabricated on 14 * 14 * 1.57 mm^3 Rogers RT5870 substrate (Er=52.33) and loss tangent of 0.0012). Bandwidth enhancement has been results due to cutting of two circular slots and by truncating the corners of the square patch gives rise to better impedance matching.. The antenna finds application in satellite communication, radar communication, and other alleged wireless communication services.

In this paper, three design has been implemented. In first design, simple square patch antenna shown in Figure 1(a) is implemented and results are analysed. In second design, corners are truncated and better results are achieved. In third design further, the two circular slots are cut in the square patch as shown in Figure 1(c) and more better results are achieved.

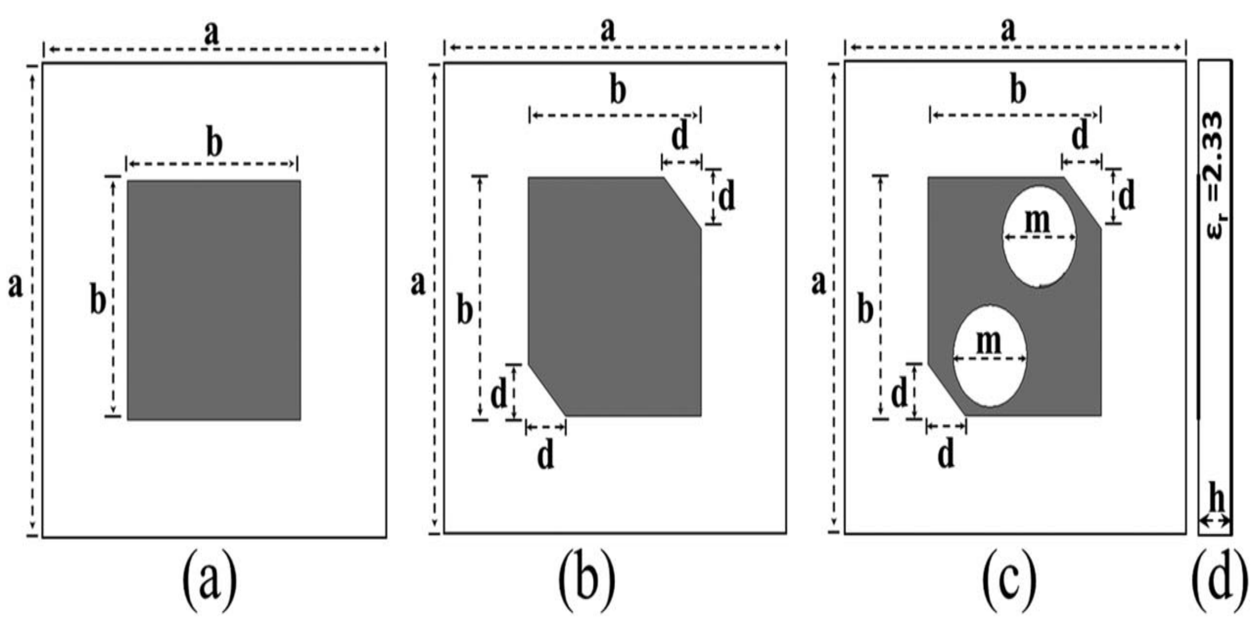

Fig. 5.1showing simple patch(a), truncated patch(b),patch with circular slots(c), side view(d)

Various steps has been taken for the implementation of the paper described above are as follow:

Step 1) Firstly we take box for the formation of substrate in the HFSS plane by giving its dimension from the paper to be implemented as shown in fig

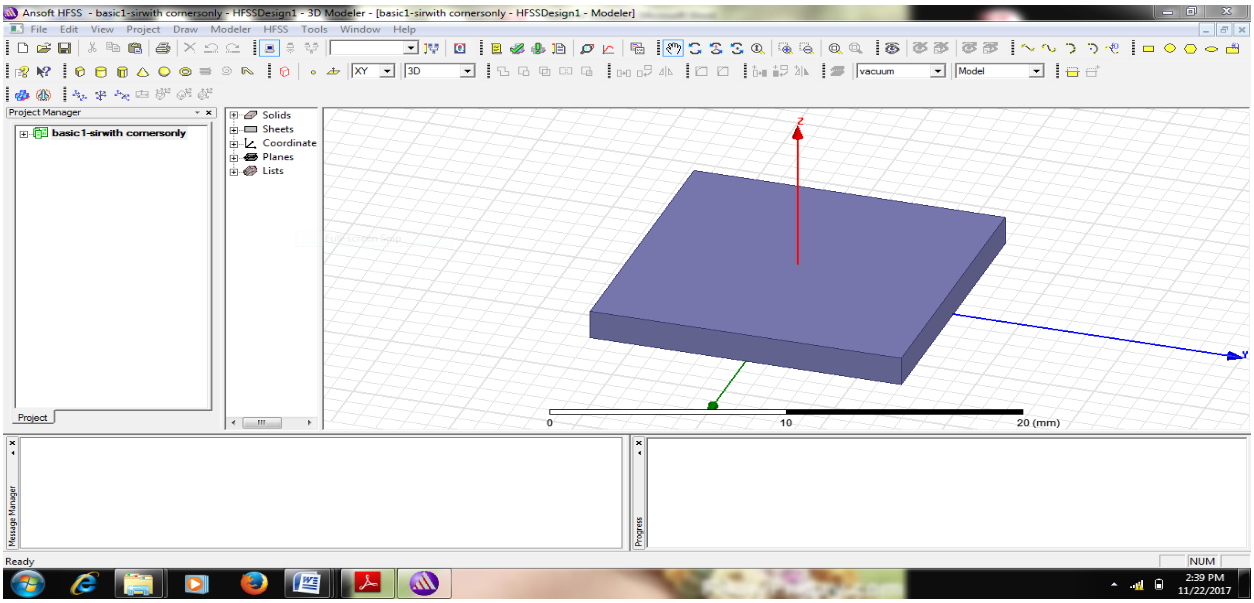

Fig. 5.2 showing substrate design in the xyz plane

Step2) Now we take rectangle for the formation of patch by providing the dimensions given in paper to be implemented as shown below

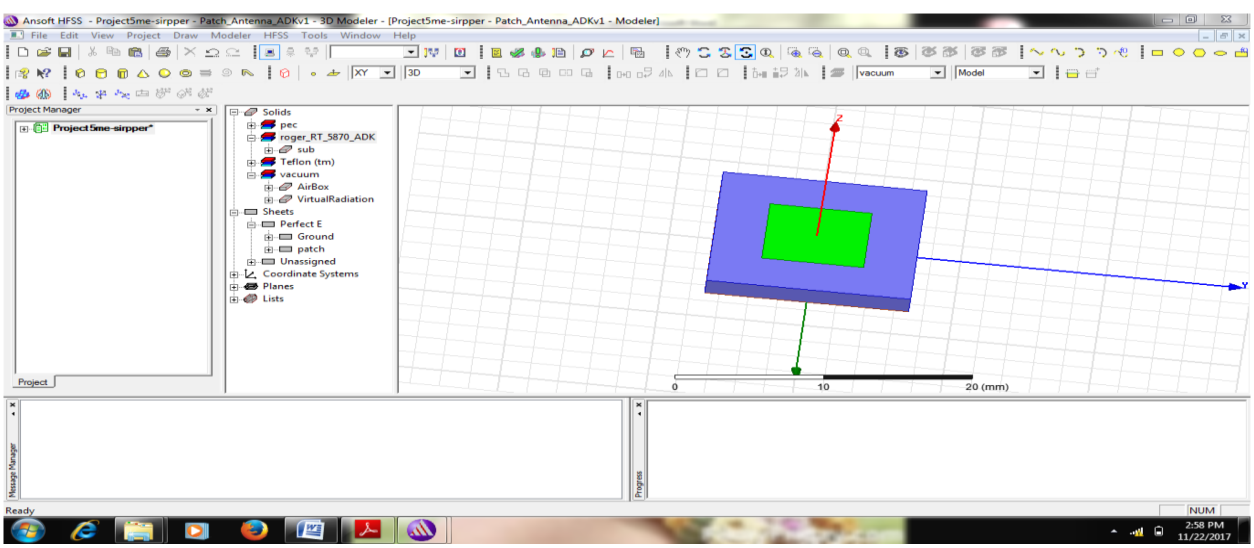

Fig. 5.3 showing patch design on substrate

Step3) now we need to form ground plane according to the dimensions provided by taking rectangle from the draw option on the top HFSS window. As we can clearly see ground plane below substrate.

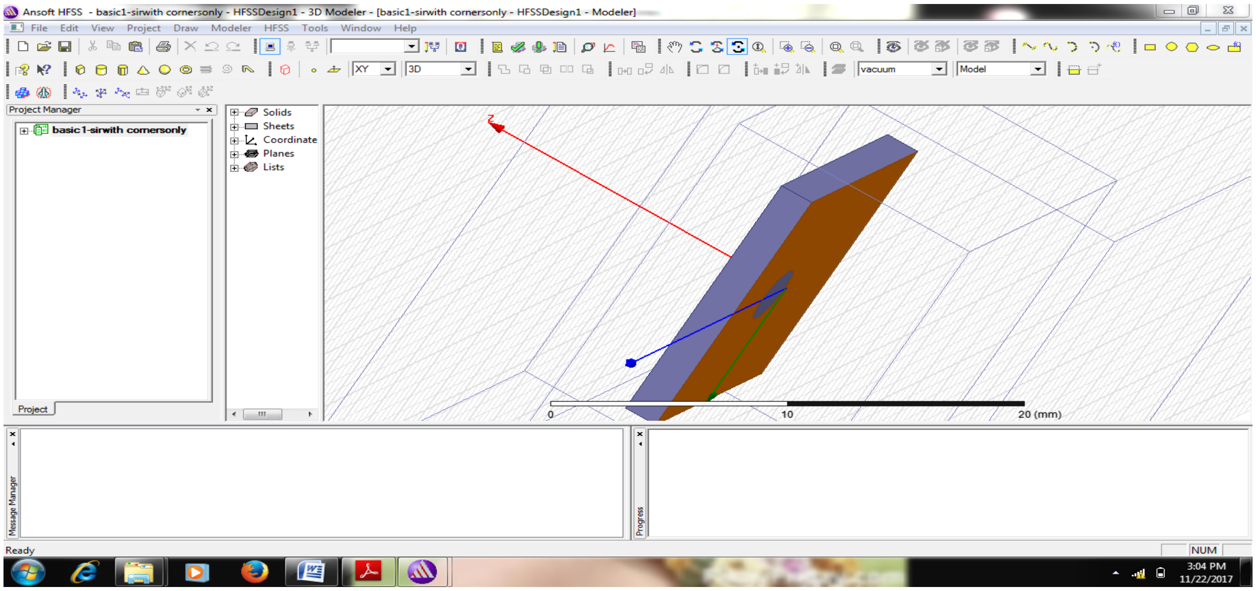

Fig. 5.4 showing ground plane on the bottom of substrate

Step4) now we provide coxial feeding by selecting the cylinder from draw. For coxial feeding, we take two cylinder having two radius inner and outer. For inner cylinder we take material Pec and for outer radius, material is Teflon.

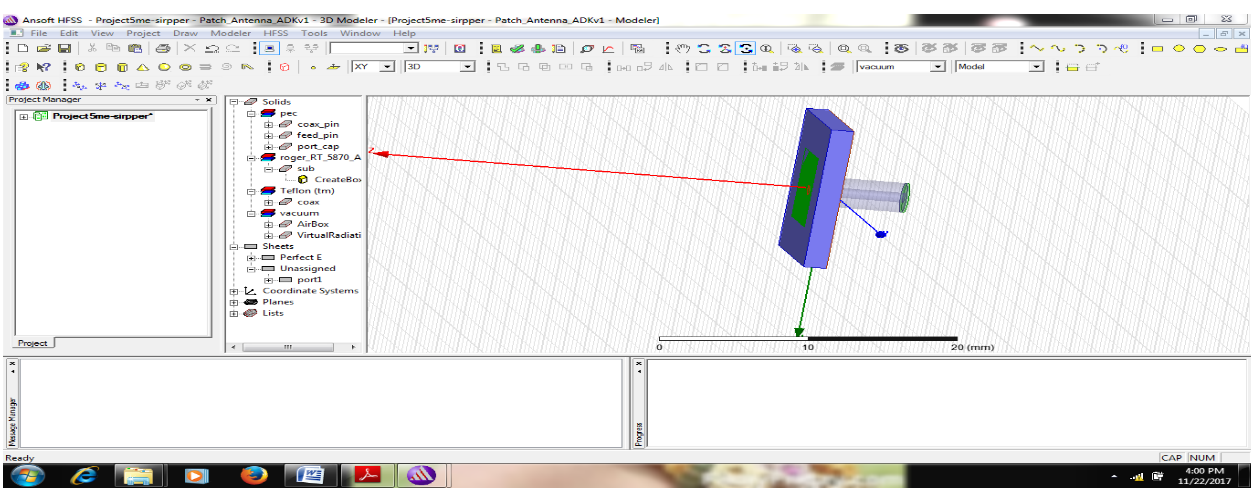

Fig. 5.5 showing coxial feeding

STEP 5) After feeding is done, we need to apply boundaries to patch , ground plane, outer coax and radiation box and excitation is applied to port.

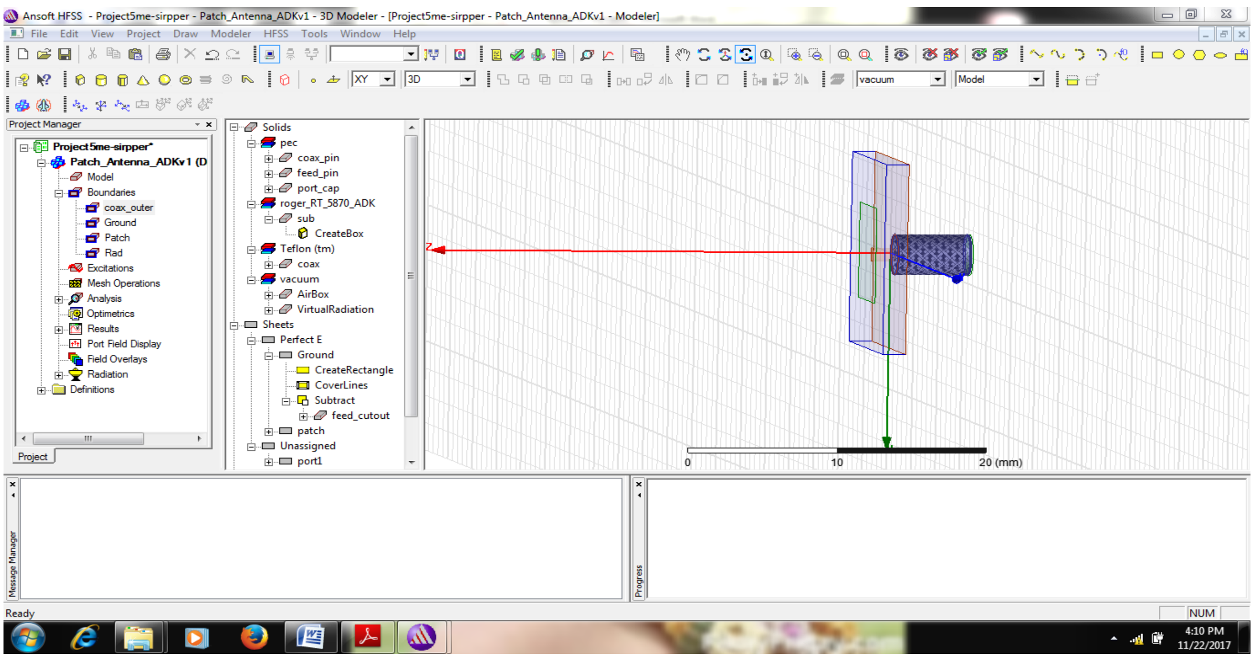

Fig. 5.6 showing assignment of boundaries and excitation

Step7) Analysis is done by adding sweep set up and assigning start and stop frequency. If whole design is complete as shown below then start simulation and check results.

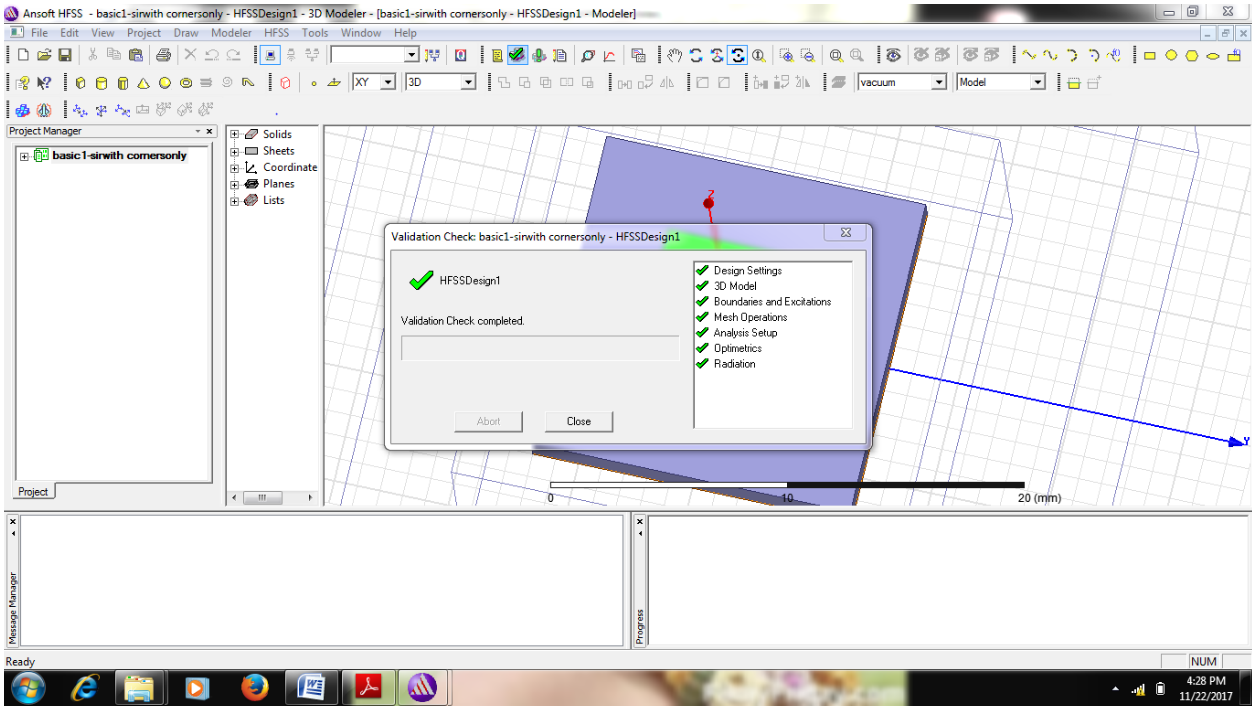

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Fig. 5.7 showing completion of design

A simple patch antenna is modified for bandwidth enhancement shown in fig. 5.8. Initially, two corners of the patch have been truncated for impedance matching as shown in fig. 5.9. Two circular slots have been introduced in the square patch for further bandwidth enhancement shown in fig. 5.10. Due to addition of circular slots, antenna starts resonating at lower frequencies whereas due to truncation of the corners, antenna starts resonating at higher frequencies, the combined effect of both gives rise to bandwidth enhancement.

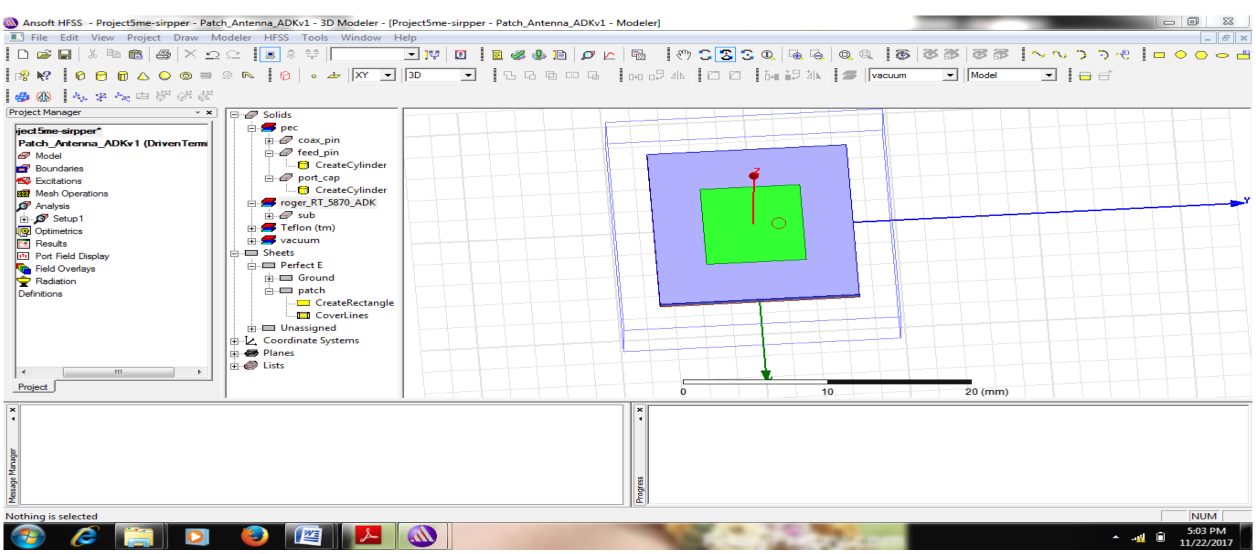

Fig. 5.8 showing design of simple patch

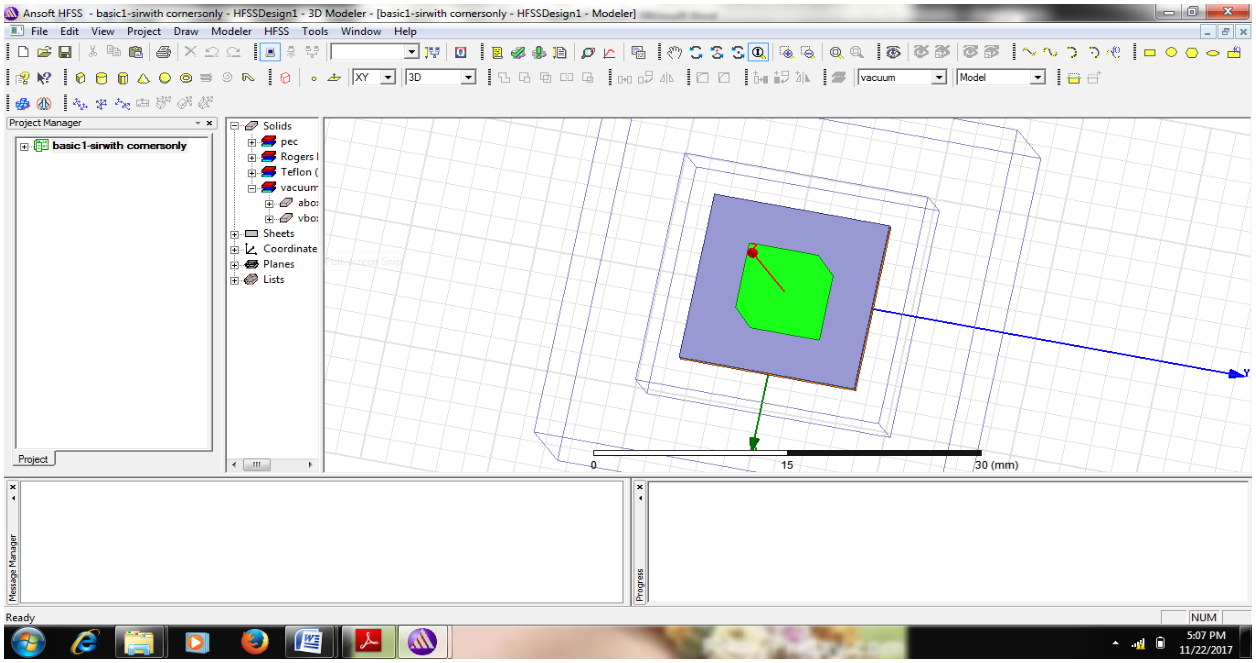

Fig. 5.9 showing design of patch with truncated corner

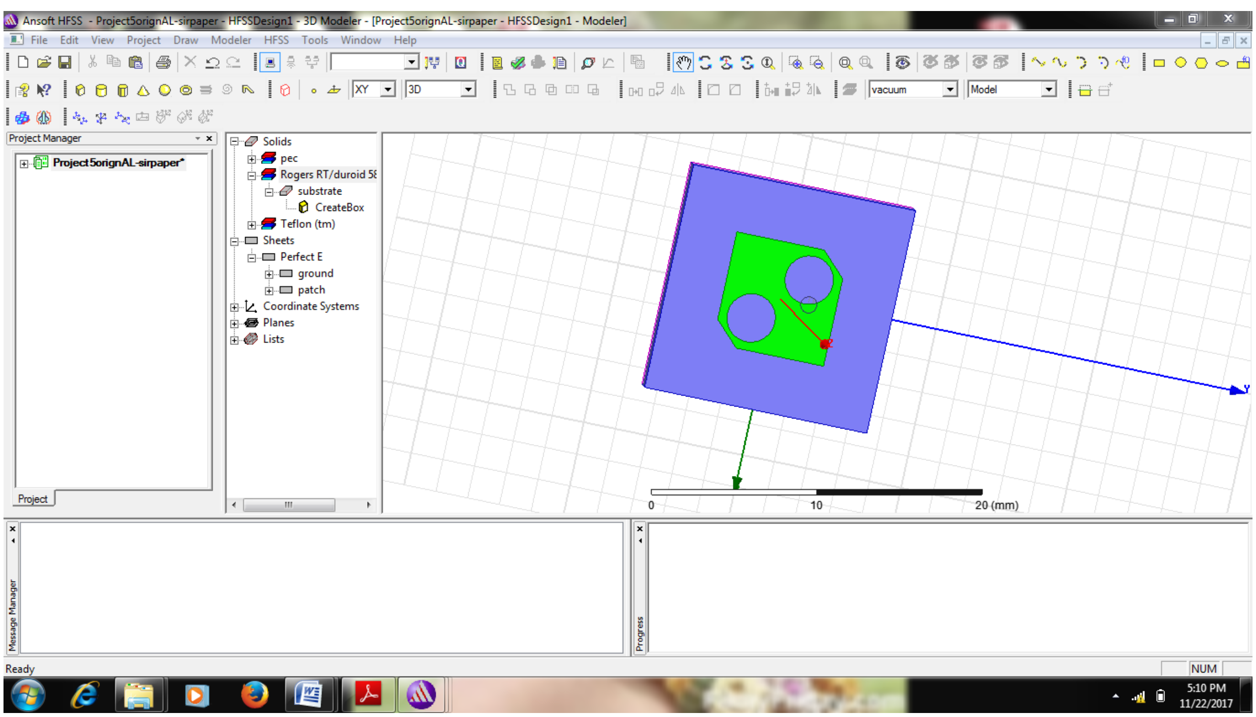

Fig. 5.10 showing design of patch with truncated corners and circular slots

	a	b	d	m	h
Simple patch antenna	14	7	-	-	1.57
Corner truncated antenna	14	7	1.5	-	1.57
Proposed antenna	14	7	1.5	3	1.57

Table2. showing the dimensions of simple patch, corner truncated and circular slots.

By implementing the above designs, we can see the difference in the results which has been discussed in results and discussion.

5.2 RESULTS AND DISCUSSION

The simulation of implemented antenna was carried out using HFSS software. First we simulate simple design that is simple rectangular patch and we can see the results in fig. 9.1. It can been seen from the return loss that after simulation of simple patch, the bandwidth is 1 GHz, with upper band at 12.5 GHz and lower at 11.5 GHz. When antenna with truncated corner was implemented, the upper band get shifted to 13.50 GHz and lower band shifted to 12.07 GHz. Further when two circular slots get introduced in the design, the corresponding modes get split and the initial mode covers the lower operating band and the second mode covers the higher operating bands. The lower band has shifted to 10.8 GHz, showing an enhancement of 1.1 GHz whereas the upper band has shifted from 13.5 to 13.2 GHz, showing deviation of 0.3 GHz. The fractional bandwidth of the proposed antenna has increased from 12.9 to 19%, showing an enhancement of 47% as compared to corner truncated patch antenna, so the overall fractional bandwidth of the proposed antenna has enhanced from 8.5 to 19%, showing an enhancement of 123% as compared to simple patch antenna. Final fractional bandwidth achieved by the proposed structure is 19% (10.8–13.2 GHz)

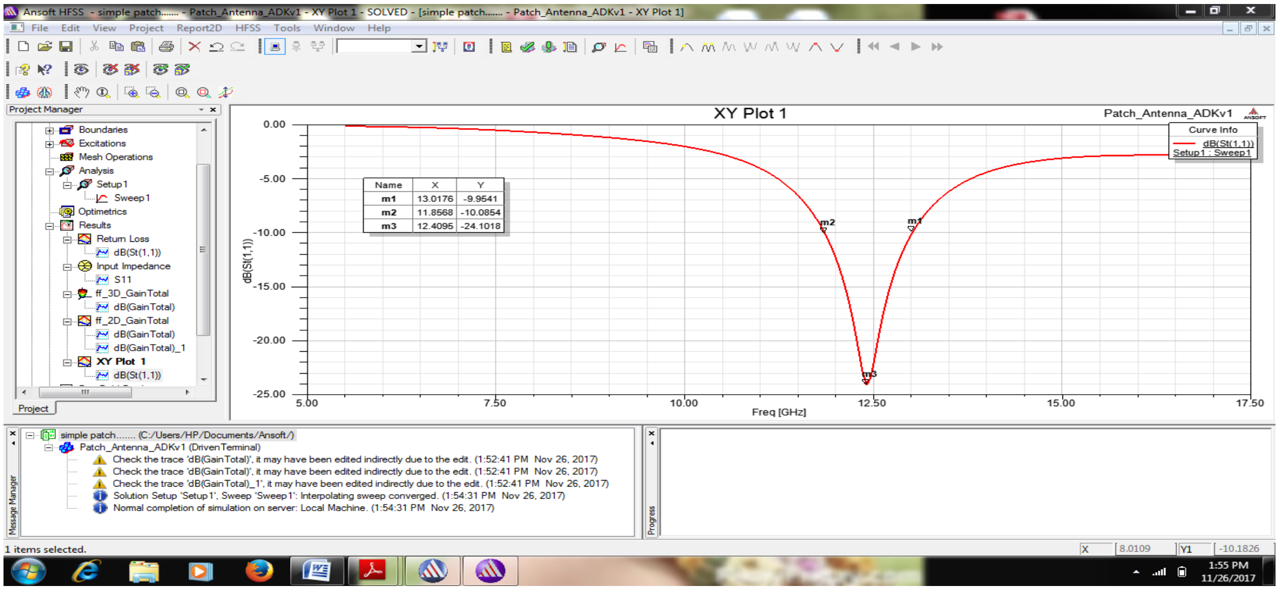

Fig. 5.11 showing return loss of simple patch.

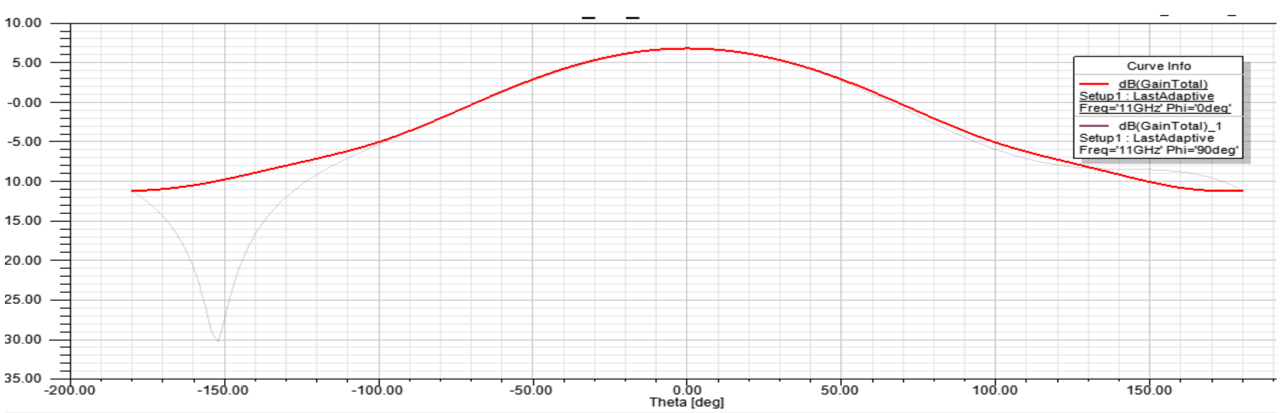

Fig. 5.12 2-D Total Gain (simple patch)

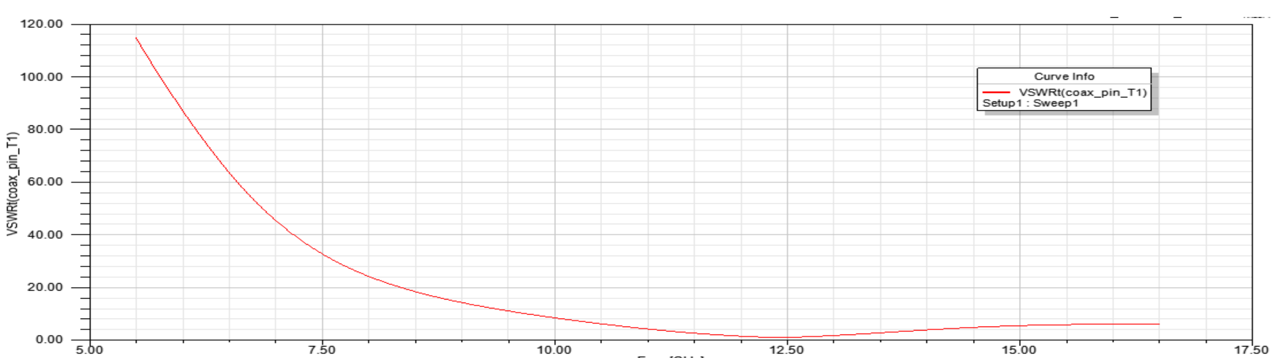

Fig. 5.13 VSWR of simple patch design

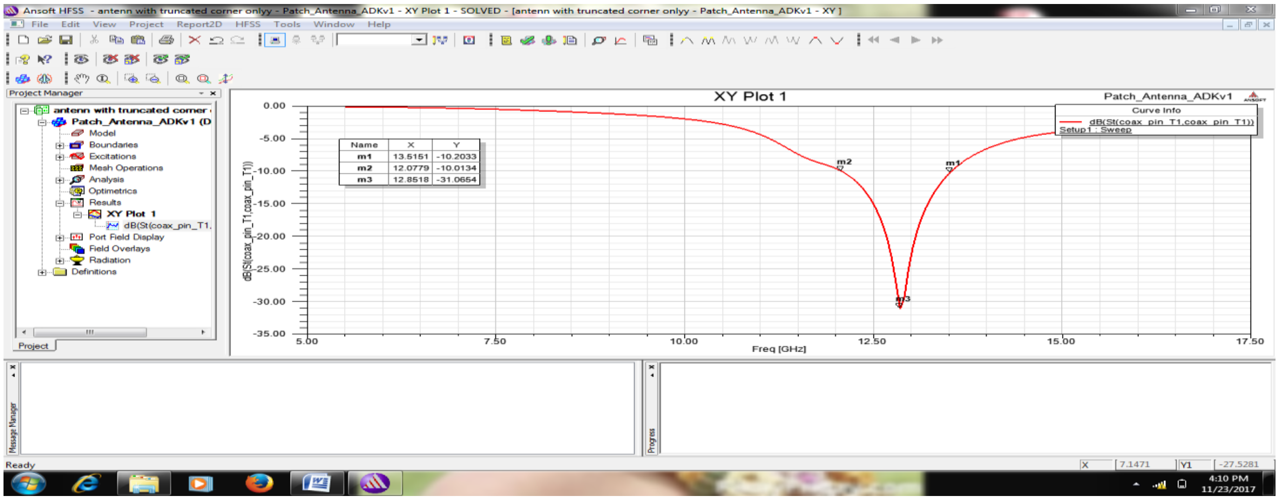

Fig. 5.14 showing return loss of antenna design with truncated corners

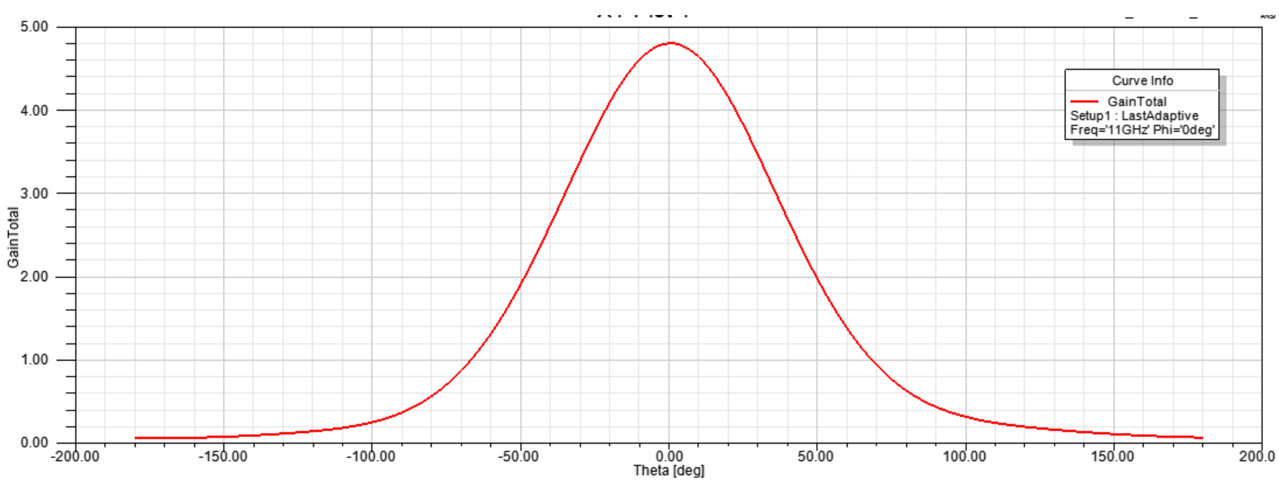

Fig. 5.15 Total Gain (truncated corners)

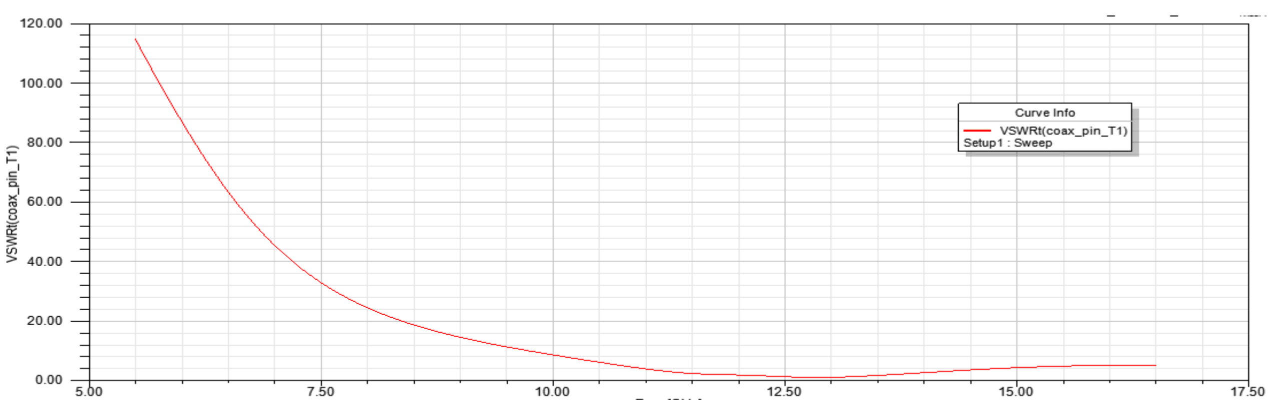

Fig. 5.16 VSWR of truncated corners

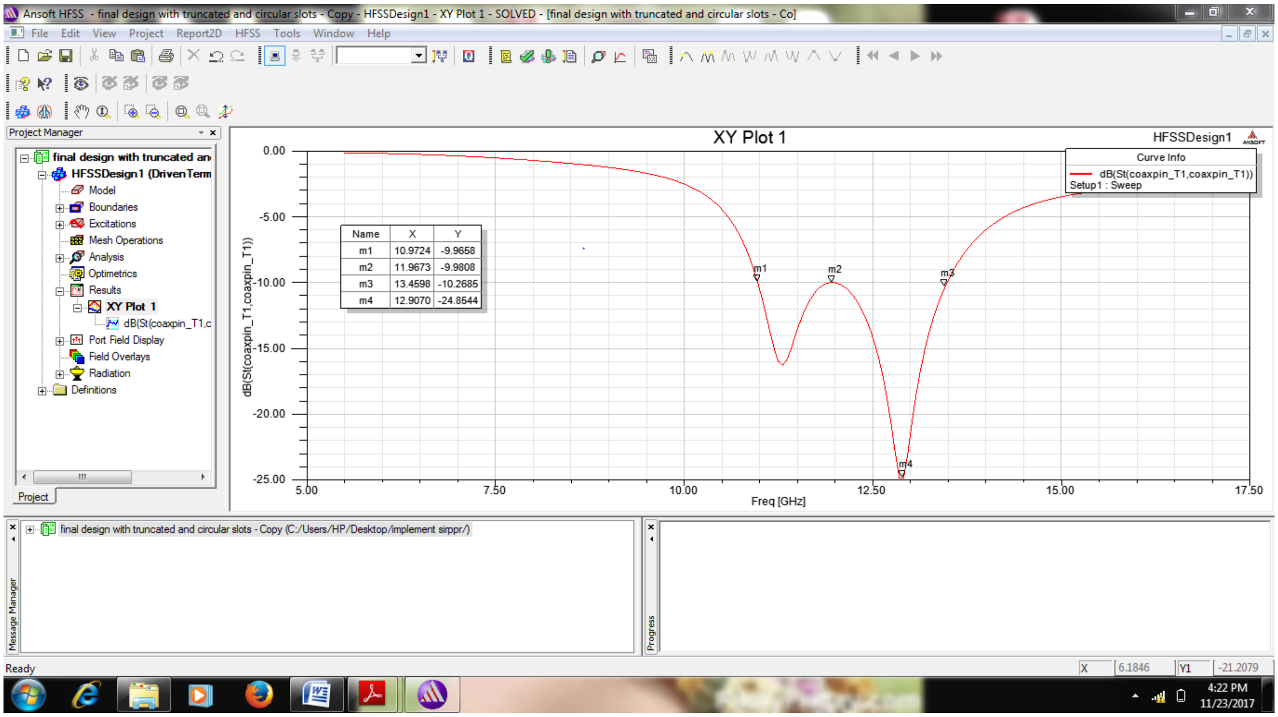

Fig. 5.17 showing the return loss of antenna of final design with truncated as well as circular slots.

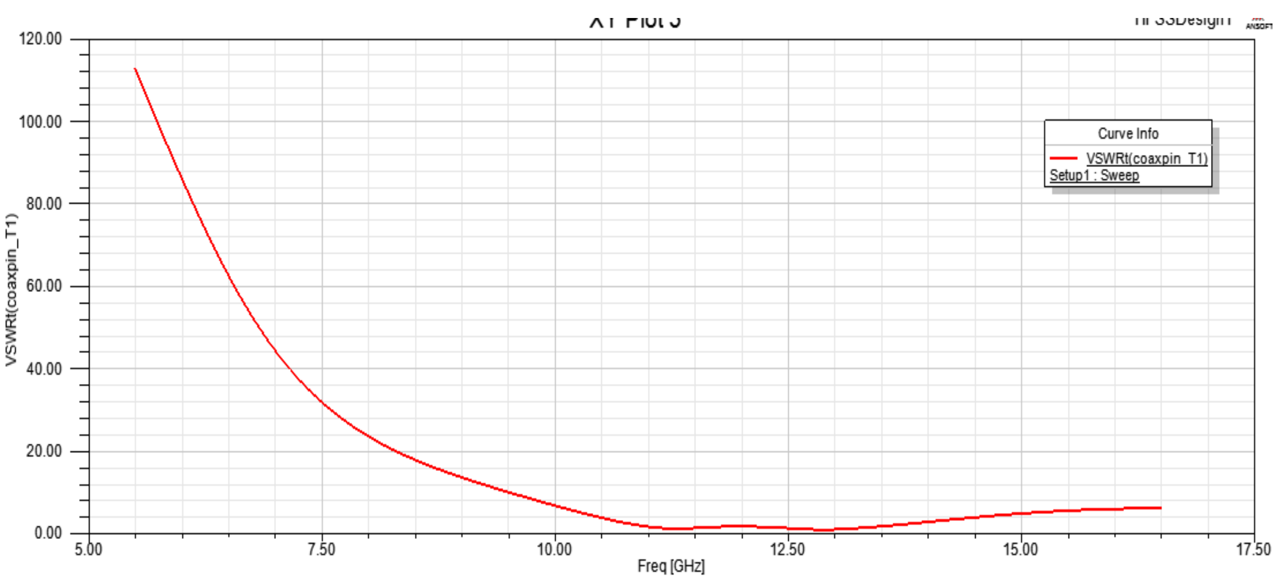

Fig. 5.18 VSWR

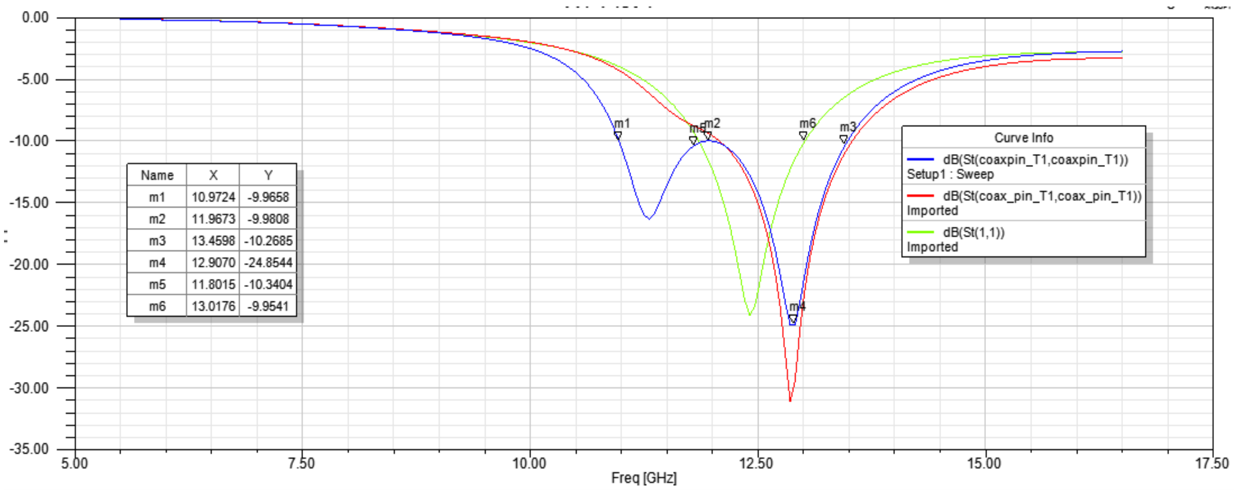

Fig. 5.19 comparison between simple patch, truncated corner patch and with circular slots.

5.3 DESIGN-2

The antenna design-2, implemented by me on HFSS is proposed by **M. Samsuzzaman et al. in 2013.** Antenna with dual band, triple frequency X shaped patch is proposed in this paper. The antenna in this paper is designed with five rectangular slots which produces dual band operation for KU band and single for K band application. The antenna gives desired results for KU/K band application and results in omni-directional and stable radiation pattern with low cross polarization. This antenna is best suited for satellite communication, Aircraft collision avoidance system.

Various steps has been taken for the implementation of the paper described above are as follow:

Step 1) Firstly we take box for the formation of substrate in the HFSS plane by giving its dimension from the paper to be implemented as shown in fig.

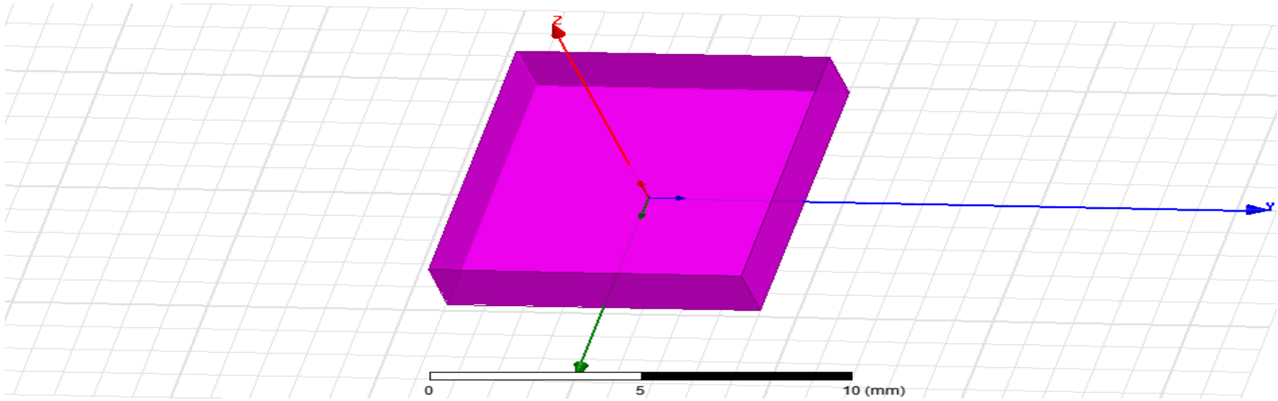

Fig. 5.20 substrate on XYZ plane

Step2) Take rectangle for patch and from DRAW, use line option for slot cutting according to dimensions

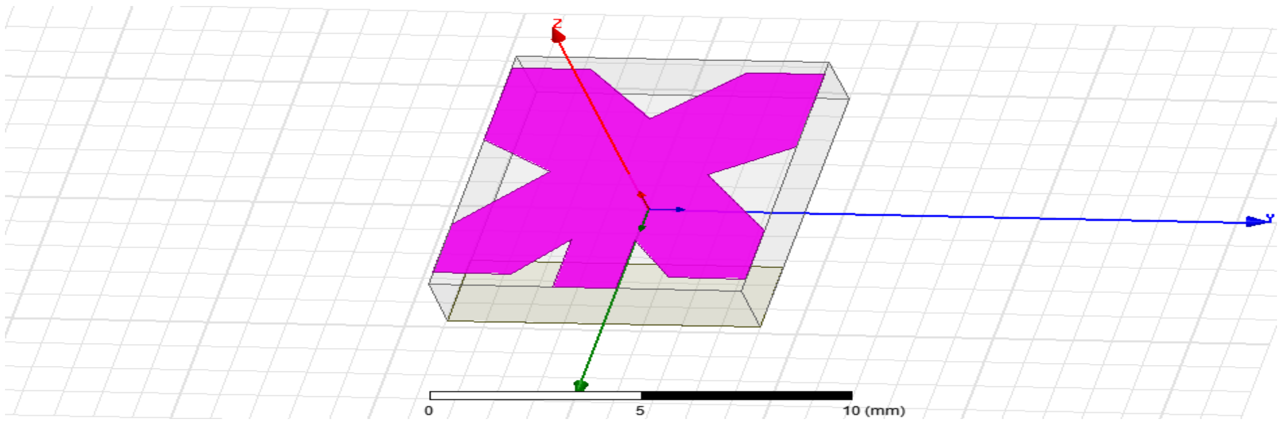

Fig. 5.21 showing patch design with five rectangular slots

Step3) Design ground plane by choosing rectangle according to dimensions provided.

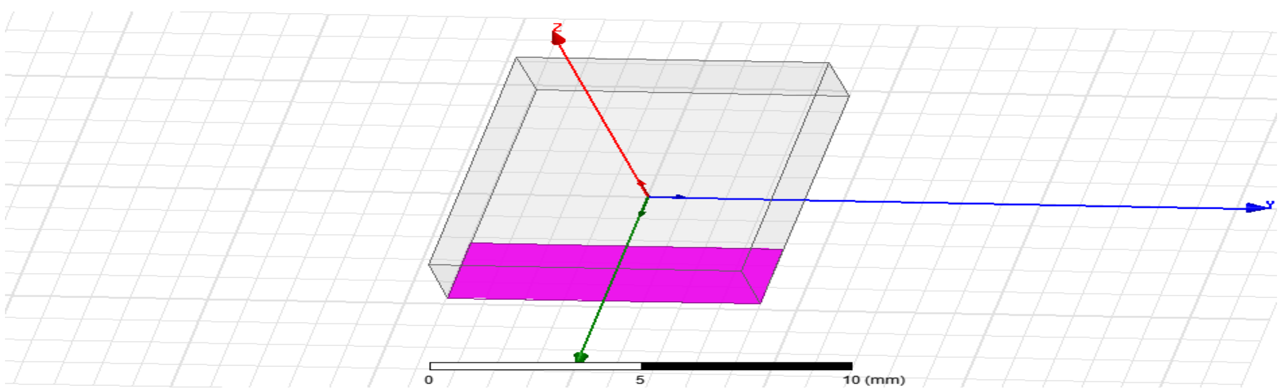

Fig. 5.22 showing partial ground plane

Step4) Design port for providing feeding to the antenna.

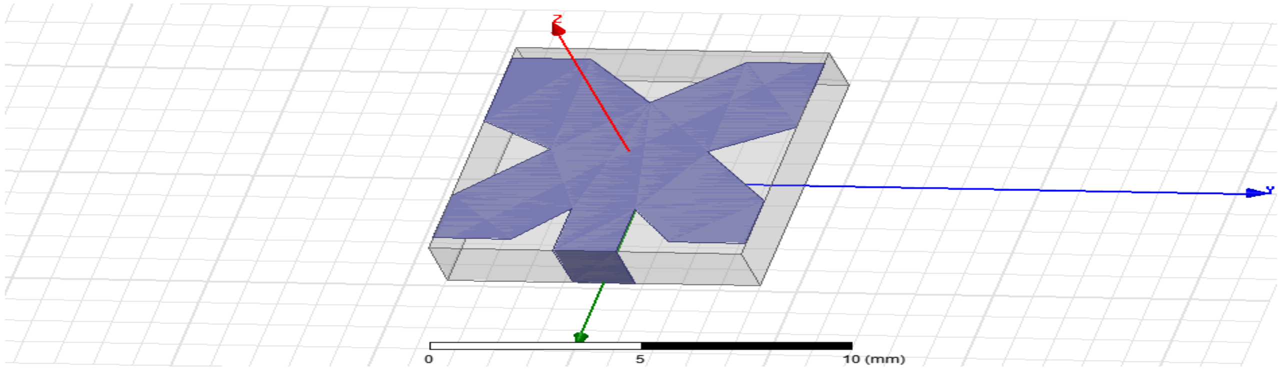

Fig.5.23 showing port for feeding

Step5) Assignment of boundaries to patch, ground plane air box and outer coax and excitation to port.

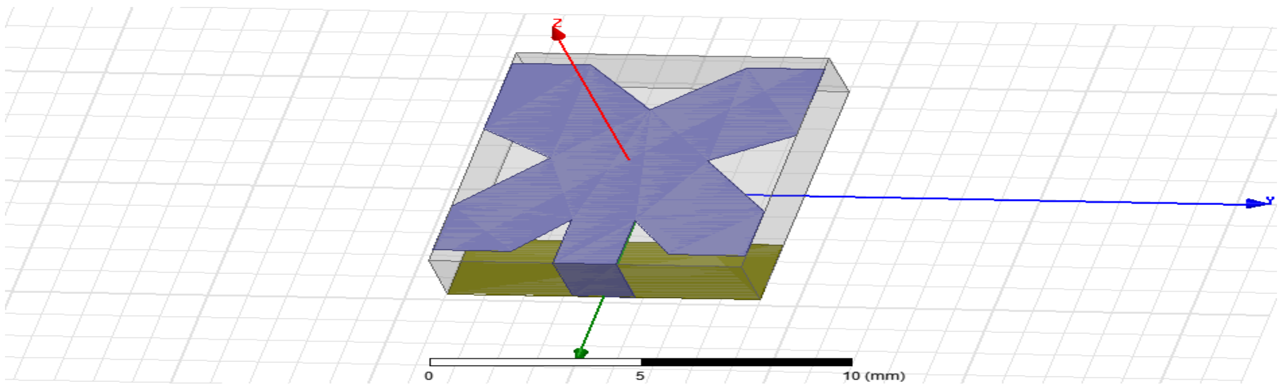

fig. 5. 24 showing complete design

5.4 RESULTS AND DISCUSSION

Return loss shows that this antenna is applicable for two bands of frequency. One is k band and other is KU bands. As results are not exactly same as that the paper, but showing good agreement with the proposed papers.

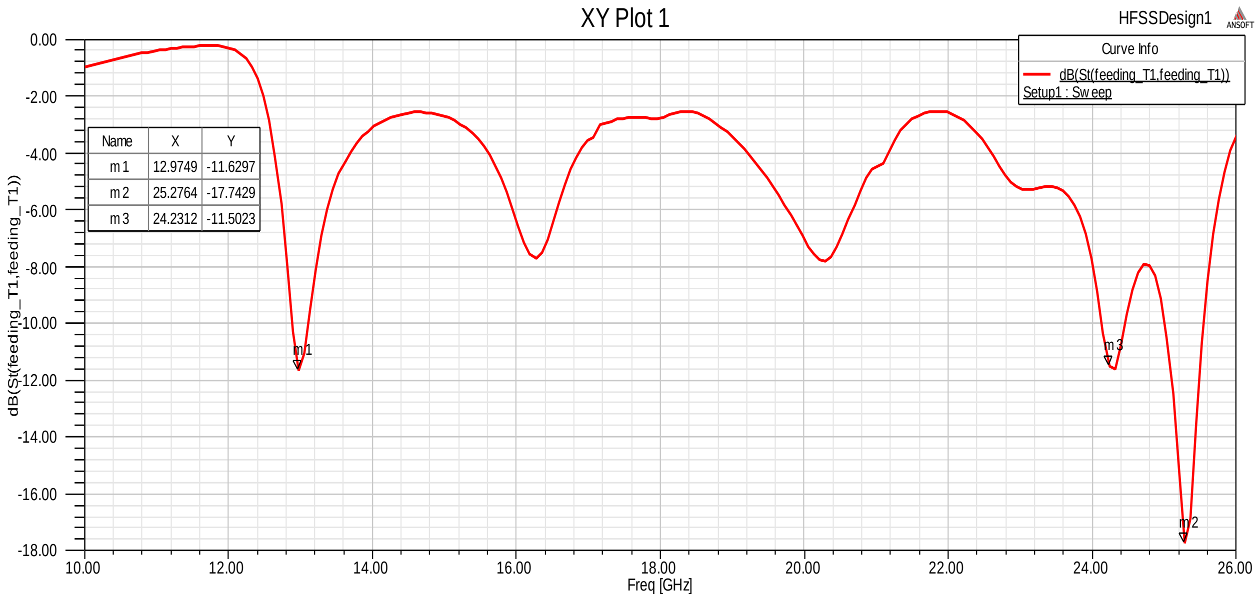

Fig. 5.25 return loss

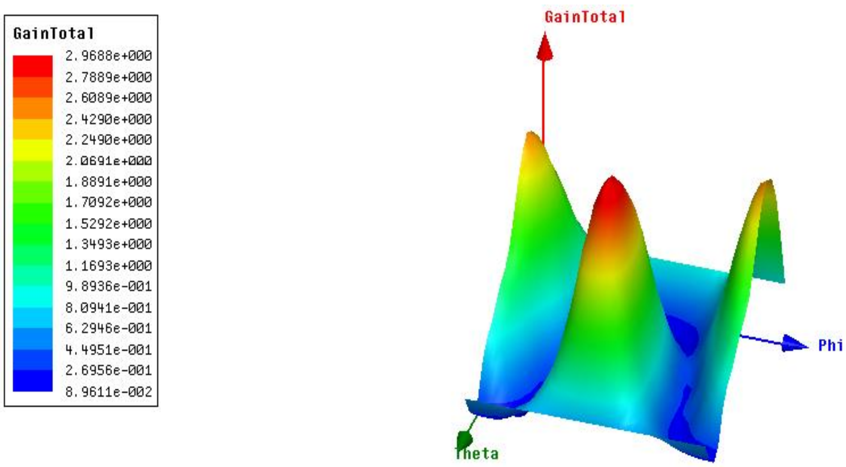

Fig. 5.26 3-D Gain

Fig. 5.27 VSWR

VSWR obtained is also within desired range as we can see from the fig. vswr <2 .

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1CONCLUSION

This implementation work on software HFSS helps to analysis the results and to differentiate between various techniques as in this implementation two techniques results in optimium results. The design gives optimum results and optimum gain of 6dB and good radiation pattern and helps to knows the various approaches to get desired results. The design miniature the size of antenna and results in better return loss, bandwidth. This antenna is well suited for satellite communication and wireless application.

By introducing techniques like truncated corner, bandwidth get enhancement and result in better reflection coefficient and by further introducing circular slots, antenna results in two resonating frequency with sufficient bandwidth and better return loss. Various papers have been reviewed to learn about techniques of making efficient antenna. This works helps to know about the software HFSS used in implementation of the design and analysis the results.

6.2 FUTURE WORK

From the knowledge, I gained from work done and implementation, I would put my best efforts to design an antenna which would produce better gain and bandwidth can be enhanced by using various techniques, I have studied in my literature review and try to give better technology to the world.

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