Design and Analysis of Monopole and DipoleAntenna at 2GHz Operating Frequency

A PROJECT REPORT
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ABSTRACT

Here we have designed and analysedMonopole and Dipole antennaare projected at c-band frequency. Resonant frequency for the antennas was taken at2GHz operating frequency,which is suitable for wireless communication,radio and telecommunication.. The HFSS simulator is used as a software environment to design and compare the antenna performance.In the design, the material named as pec (Perfect Electrical Conductor) is used for both antennas. It has been found that the monopole antenna shows -16.88dB return loss, 6.99 Q factor, while the dipole antenna shows -20.11 dB return loss, 5.55 Q factor, and front-to-back ratio of 1.0037.The impedance, directivity, gainand the far field radiation patterns of resultant antennas have been observed.

SUPERVISOR

Mr.BISWA RANJAN BARIK

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INTRODUCTION

The first antennas were built in 1888 by German physicist Heinrich Hertz in his pioneering experiments to prove the existence of electromagnetic waves predicted by the theory of James Clerk Maxwell. Hertz placed dipole antennas at the focal point of parabolic reflectors for both transmitting and receiving . He published his work in Annalen der Physik and Chemie (vol. 36, 1889).

An antenna is an electrical device which converts electric currents into radio waves and vice versa. It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter applies an oscillating radio frequency electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). The need for antennas arisen when two-person wanted to communicate between them when separated by some distance and wired communication is not possible. Antennas are required by any radio receiver or transmitter to couple its electrical connection to the electromagnetic field. Radio waves are electromagnetic waves that carry signals through the air (or through space) at the speed of light with almost no transmission loss.

The monopole antenna was invented in 1895 and patented 1896 by radio pioneer Guglielmo Marconi during his historic first experiments in radio communication. He began by using dipole antenna invented by Heinrich Hertz consisting of two identical horizontal wires ending in metal plates. He found by experiment that if instead of the dipole, one side of the transmitter and receiver was connected to a wire suspended overhead, and the other side was connected to the Earth, he could transmit for longer distances. For this reason the monopole is also called a Marconi antenna, although Alexander Popov ndependently invented it at about the same time.

The dipole antenna is the most efficient class of antenna in radio and telecommunication field. The dipole antenna whose radiation pattern produced is approximately equal to a radiating structure which is having an elementary structure. In dipole antenna, feed line is connected between the two conductors of equal length providing end to end connection. Dipole antennas are highly preferred to act as resonant antennas. Feed point plays a vital role in this kind of antenna. When the feed point is shorted, then the antenna is able to resonate at a particular frequency. E.g. Guitar. It is very useful for operating the antenna at particular frequency in terms of feed point impedance. Hence, the length of the feed point decides the frequency of operation. Out of these all, the use of center-fed-half-wave dipole is literally high. The dipole antenna act as omni directional when it is installed vertically and act like weekly directional antenna when it is installed horizontally. Nowadays, most of the antennas used is to be seen as based on the dipole. Many directional antennas like horn, parabolic, reflector is feed by dipole antennas. It is already analyzed that vertical antennas on the base of dipole antenna design which is half of vertical antenna.

In normal applications, shorter dipoles are used frequently and preferred where full half-wave dipole is larger in size . The Hertzian dipoles are used to analyze this kind of antenna. Though these dipole antennae are shorter than a resonant antenna, the feed point impedance of dipole antenna includes a capacitive reactance which is chose to be very large in order to be practical and is used especially as a type of transmitting antenna.

Now days, wireless communication systems are becoming increasingly popular. However, the technologies for wireless Communication still need to be improved further to satisfy the higher resolution and data rate requirements.In the communication system the more things is look to is the cost and low power device and it is the monopole which previous thing is used and still be improve for the communication system.

Monopole is a type of the radio antenna formed by replacing one half of a dipole antenna with a ground plane at right angles to the remaining half. If the ground plane is large enough, the monopole behaves exactly like a dipole, as if its reflection in the ground plane formed the missing half of the dipole.

Mostly the monopole antennas are widely used in mobile and wireless communications because of their easycompatibility but this monopole antenna suffer due to theirlow BW. And lose of radiating energy which will affect its performance. So we use this structures to improvise its parameters and it is explained in ref. Now here we use pec material for the designed model is simulated by using HFSS software andthe simulated results are presented.

LITERATURE SURVEY

This chapter provides a brief review of the past work in the Antenna field. The theoretical and experimental work in type of wire antennas around the world is illustrated. The first section briefly describes various developments in themonopoleantennas. The second section deals with dipole antenna design while the third part describes various both antenna designs employed recently in modern communication. This chapter also illustrates analytical and full wave solutions of monopole and dipole antennas.

Like dipole antenna, a monopole has an omnidirectional radiation pattern it radiates with equal power in all azimuthal directions perpendicular to the antenna. However, the radiated power varies with elevation angle, with the radiation dropping off to zero at the zenth of the antenna axis. It radiates vertically polarized radio waves.

Nowadays,the monopole and dipole antennas are most efficient type of antennas which are used in the commerical purposeslike wireless communication,radio and telecommunication field. The antenns having many advantages like wider bandwidth, higher radiation efficiency, smaller in size,flexible,low cost, fast installation,less weight,simple geometry etc.. makes them as obvious choice.A monopole antenna is the type of radio class antenna or resonant antenna that consists of a straight rod shaped structure conductor,perpendicularly mounted over the ground plane.The impedance of monopole antenna is half of full dipole antenna and the directivity is directly related to that of dipole antenna.The types of monopole antenna are whip,rubber ducky,helical,random wire, umbrella, inverted-L and T-antenna,inverted-F,mast radiator and ground plane antennas.

Monopole and Dipole antennas have been designed from the early time and many designs were developed for greater efficiency. This chapter discusses briefly various designs proposed earlier in literature.

Martha Gonzalez J., Carlos Suárez F. and Gustavo Puerto L[1] proposed design of BROADBAND DIPOLE ANTENNA FOR DOA SYSTEMS APPLICATIONS.In this paper presents an antenna design with Right Hand Circular Polarization (RHCP) for applications in

estimation systems of Direction of Arrival (DOA). The antenna is composed by orthogonal bowties dipoles or "Bow-Tie" and it is placed in front of a ground plane, achieving a wide impedance bandwidth and Axial Ratio (AR). The center frequency is 2.2 and has a 72 total size. Measurements results of the implemented prototype showed a maximum gain of 6.88 and 42.34% impedance bandwidth for a (S11) <= -10dBand 26.91% axial ratio for (AR)<=-3dB.

Suci Rahmatia, Enggar Fransiska DW, Nurul Ihsan Hariz Pratama, Putri Wulandari,Octarina Nur Samijayani [2] has designed Designing Dipole Antenna for TV Application

and Rectangular Microstrip Antenna Working at 3 GHz for Radar Application.In this paper presents two antenna design, the first antenna design a dipole antenna made of two material, aluminum and iron to works at TV channel frequency (450MHz-950MHz) in Jakarta, Indonesia. The second antenna design is a rectangular microstrip antenna with line feed method for radar application such as weather radar working on S-band at 3GHz frequency, we used rectangular shape because it is the simplest design of microstrip antenna. The paper methodology is to determine the frequency range the simulation will use, then design the antenna and start the simulation. Performance investigation of the design

conducted by observing the bandwidth, return loss, and radiation of both antenna insimulation. For the rectangular patch

antenna, determining the patch width, length and dielectric constant are the major critical parameters are needed. The simulation results show the comparison of performance between

the dipole antenna two materials and the rectangular microtsrip patch antenna's performance using the dimension of selected parameters.

Dr. Sumit Kumar Gupta, Harish Kumar Jangam, Nipun Sharma[3] explained about the types of antennas gives you a brief introduction about antenna .advantage, disadvantage & careers of antenna Types of antenna, Dipole antenna,. Half-wave Folded Dipole, The characteristics of each type of antenna and antenna application. This paper is not a comprehensive study of antennas, but serves as an introduction to antenna types and their applications.

Mohammad Tareq,Dewan Ashraful,Mazidul Islam,Razin Ahmed [4], a simple half-wave dipole antenna has been designed and analyzed for wireless applications. Resonant

frequency for the dipole antenna was 5 GHz and as a simulation tool CST Microwave Studio (MWS) has been used. After that the return loss curve, the VSWR and the farfield radiation patterns of the half-wave dipole antenna have been observed.There is a gap between two arms of half-wave dipole antenna for feeding purpose. Here L is the total length of the antenna, D is the thickness of antenna arm and g is the feeding gap. Radiation resistance of the half-wave dipole is 73 Ohm which matched with the line impedance.

P. **Revathy,T.Anand Kumar&R.S.Rajesh[5],**demonstrates a dipole antenna is the most efficient RF based Antenna which can be developed from a part of a more complicated antenna array.This paper mainly aimed in making the efficient dipole antenna .The dipole antenna is one of the highest gains producing antenna and highly used in radio and telecommunication field.The efficiency level of this antenna is very high.The dipole antenna is designed using the HFSS v13 software and impedance,directivity,gain are examined.

AymenEmhemed G. Alkurbo, Ateff M.Enkib, Youssef Amer Mohamed

Arebi, Mahmoud Salem Farhat[6],to design an antenna ,especially broadband momopole planar rectangular antenna that was printed on printed circuit board(PCB) consists of a rectangular patch and ground plane.The simulation software that is used is Ansoft HFSS that can be used for simulating and desinging the antennas .Eve.n though the simulation resullts and measurementsresult of presented antenna has differences both of them can be work at frequency range 1.5GHz until that means can be used for commercial communication such as HSDPA, Wimax,Bluetooth and wifi.This suggest that once the antenna is a broadband antenna that has very large bandwidth.

B. **N. Balarami Reddy, Sandeep Kumar P., T. Rama Rao*, Nishesh Tiwari, and M. Balachary[7],**has designed and analysed theDesign and Analysis of WidebandMonopole Antennas for Flexible/Wearable Wireless Device Applications.Compact wideband flexible monopole antennas are designed and analyzed for its performance for Body Centric Wireless Communications (BCWC). Two antennas with identical radiators on different substrates are designed and fabricated on polyamide and teslin paper substrates, deploying a modified rectangle-shaped radiator. With the aid of modifications in the radiating plane and defecting the ground plane, the polyamide based antenna is designed to operate between 1.8 and 13.3 GHz, and teslin paper based antenna is designed to operate between 1.45 and 13.4 GHz to cover the wireless communication technology frequencies and ultra-wideband range for various wireless applications. The reflection coefficient characteristics of the fabricated antennas on free space and on various sites of the body are measured and match reasonably well with the simulated reflection coefficient characteristics. The specific absorption rate (SAR) analysis is also carried out by placing the antennas.

Kalpana Chikatwar , Boya Satyanarayana , Dr. S. N. Mulgi[8],Design and Development of Simple Rectangular Monopole Antenna for Wideband Operation.This paper presents the design and development of simple rectangular monopole microstrip antenna (RMA) for wideband operation. The proposed antenna operates from 1.54 to 4.62GHz and gives an impedance bandwidth of 100% which is 32.46 times more than the impedance bandwidth of conventional rectangular microstrip antenna (CRMA). The RMAhas been realized from CRMA by modifying the microstripline feed of CRMA which further simplifies the geometry of RMA. The peak gain of RMAin its operating band is found to be 7.08 dB which is 3.35 times more than the peak gain of CRMA. The antenna characteristics such as return loss, radiation pattern etc. Are discussed.ths antenna used as the applications of WIMAX and WLAN.In many modern wireless applications where physical size, weight, cost, performance of the device, ease of installation, simple structure and aerodynamic profile are required . The low profile antennas like microstrip antennas (MSAs) are the best choice. However, MSAs inherently have narrow impedance bandwidth (BW) and low gain . Many researchers have made efforts continuously to overcome the demerits of narrow impedance bandwidth. Various techniques such as use of different geometries, slot loading, use of different feeding techniques etc. have been presented to improve the antenna performances.

ANTENNA PARAMETERS

An antenna is the basic fundamental component of the communication system. Antennas are nothing but links between the transmitter-to-free pace or free spacereceivers. The characteristics of the communication system are mainly dependent on the characteristics of the antennas used in the system. Antennas used in different systems are of different types. In some, systems the operational characteristics of the system are designed around the directional properties of an antenna. Or in some other type of system, the antennas are used only to radiate energy in all directions equally i.e. omnidirectional property. Now the applications of antennas are different in different systems. But irrespective of antenna types and applications, all the antennas possess certain fundamental properties are listed below:

3.1 Radiation pattern:

The basic term “radiation” means that, the distribution of power through respective fields of the antenna. An antenna radiation pattern or antenna pattern is defined as “A mathematical function or a graphical representation of radiation properties of the antenna as a function of space coordinates”. However, in most cases, the radiation pattern is determined in the far-field region and is represented as a function of directional coordinates. The properties of Radiation are power flux density, radiation intensity, field strength, directivity phase or polarization. The radiation properties of most concern are the two or three-dimensional spatial distribution of radiated energy as a function of the observer’s position along a path or surface of a constant radius. A trace of received power at a constant radius is called power pattern. On the other hand, a graph of spatial variation of the electric (or magnetic) field along a constant radius is called amplitude field pattern. In practice, the dimensional pattern is measured and recorded in a series of twodimensional patterns [16].

3.2 Radiation Intensity:

The radiation intensity of an antenna does not depend on the distance from the radiator or antenna. It is denoted by U. The radiation intensity is defined as power per unit.

$$U(\theta,\phi) = \mathrm{r}^2\, p_d(\theta,\phi)$$

Then the total power radiated can be expressed in terms of radiation intensity as,

$$p_{rad} = \int_{\phi=0}^{2\pi} \int_{\phi=0}^{\pi} \mathrm{U}(\theta, \phi)\, d\Omega$$

$$\text{Where } d\Omega = \ sin\theta\ d_{\emptyset} d_{\emptyset}$$

Thus the radiation intensity U (θ, ϕ) is expressed in watts per steradian (W/S_r) and it is defined as time average power per unit solid angle. The average value of the radiation intensity is given by

$$U_{avg} = \frac{P_{rd}}{4\pi}$$

Using radiation intensity U (θ, ϕ) we can also calculate normalized power pattern as the ratio of radiation intensity U (θ, ϕ) it is maximum value U $(\theta, \phi)_{max}$ and is given by,

$$p_{dn} = \frac{\mathrm{U}\ (\theta, \phi)}{\mathrm{U}\ (\theta, \phi)\mathrm{max}}$$

3.3 Directivity:

In 1983, version of the IEEE standard definition of terms for antennas, there has been a substantive change in the definition of directivity, compared to the definition of the 1973 version. The term directivity in the new 1983 version has been used to replace the term directive gain of the old 1973 version. In the 1983 version, the term directive gain has been deprecated. According to authors of the new standard, this change brings this standard in line with common usage among antenna engineers and with other international standards notably those of the international electrochemical commission (IEC) therefore directivity of an antenna defined as the ratio of radiation intensity is given direction from the antenna to the radiation intensity averaged over all directions. The average radiation intensity is equal to the total power radiated by the antenna divided by 4 . if the direction is not specified the direction of maximum radiation intensity is implied. Stated more simply the directivity of the non-isotropic source is equal to the ratio of its radiation intensity in a given direction over that of the isotropic source.

$$D = \frac{U}{U_0}$$

$$D_{max=D_0} = \frac{U_{max}}{U_0} = \frac{4\pi U_{max}}{P_{rad}}$$

D=Directivity

D0=Maximum directivity

U=Radiation intensity (W/unit solid angle)

Umax=Maximum radiation intensity (W/unit solid angle)

U0=Radiation intensity of an isotropic antenna (W/unit solid angle)

Prad=Total radiated power (W)

$$D0 = D\theta + D\phi$$

$$D\theta = \frac{4\pi U_\theta}{(p_{rad})_{\theta+((p_{rad})}\phi}$$

$$D\phi = \frac{4\pi U_\theta}{(p_{rad})_{\theta+((p_{rad})}\phi}$$

3.4 Gain:

Another useful measure describing the performance of the antenna is the gain. Although the gain of the antenna is closely related to the directivity, remember that directivity is a measure that describes only the directional properties of the antenna, and it is therefore controlled only by pattern. The absolute gain of an antenna is defined as the ratio of intensity, in a given direction to the radiation intensity that would be obtained if power accepted by antenna was radiated isotropically. The radiation intensity corresponding to isotropically radiated power is equal to the power accepted by the antenna divided by 4.In equation form this can be expressed as

$$Gain = 4\pi \frac{\text{radiation intensity}}{total\ input\ accepted\ power} = 4\pi \frac{U(\theta, \emptyset)}{p_{in}}$$

In most cases, we deal with relative gain, which defined as the ratio of power gain in a given direction to the power gain of reference antenna in its reference direction. The power input must be the same for both antennas the reference antenna usually a dipole horn or any other antenna whose gain can be calculated or it is known. In most cases, however, the reference antenna is a lossless isotropic source.

The maximum power gain can be defined as the ratio of the maximum radiation intensity to the radiation intensity due to isotropic lossless antenna.

$$G_{p_{max}} = \frac{Maximum\ radiation\ intensity}{Radiation\ intensity\ due\ to\ isotropic\ loseless\ antenna}$$

For many practical antennas, the radiation efficiency ƞr is 100%. Then the maximum power gain is approximately the same as the directivity or the maximum directional gain of the antenna. Generally, both power gain and the directional gain are expressed in decibels(dB).

3.5 Antenna efficiency:

The practical antenna is made up of a conductor having finite conductivity. Hence we must consider the ohmic power loss of the antenna. If the practical antenna has ohmic losses.

3.6 Half power beam width:

The half-power beam width is defined as in a plane containing the direction of the maximum of a beam the angle between two direction in which the radiation intensity is one half the maximum value of the beam often the term beam width is used to describe the angle between any two-point on the pattern such as the angle between 10-dB points. In this case, the specific point on the pattern must be described as the 3- dB beam width. The beam width of the antenna is a very important figure of merit and is often used as a trade-off between it and side lobe level; that is as the beam width decreases the side lobe increases and vice versa. Also, the beam width of the antenna is used to describe the resolution capabilities of the antenna to distinguish between two adjacent radiating sources or radar targets. The most common resolution criterion states that the resolution capabilities of the antenna to distinguish between two sources is equal to half the first null beam width (FNBW/2) which is usually used to approximate the half-power beam width (HPBW). That is two sources separated by an angular distance equal to or greater than FNBW/2 = HPBW of an antenna with uniform distribution can be resolved. If the separation is smaller ten antennas will tend to smooth the angular separation distance [16].

3.7 Bandwidth:

The bandwidth of an antenna is defined as the range of frequency with which the performance of antenna concerning some charters tics conforms to the specified standard. The bandwidth can be considered to be a range of frequency on either side of centre frequency where the antenna characteristics are within the acceptable value of those at the centre frequency. For a broadband antenna, the bandwidth is usually expressed as the ratio of upper to lower frequency of acceptable operation. Because the characteristics of an antenna do not necessarily vary in the same manner or are even critically affected by the frequency there is no unique characterization of the bandwidth.

3.7.1 Frequency Bandwidth:

Narrowband - These antennas cover a small range of the order of few percents around the designed operating frequency.

3.7.2 Impedance Bandwidth:

The impedance variation with frequency of the antenna element results in a limitation of the frequency range over which the element can be matched to its feed line. Impedance Bandwidth is usually specified in terms of a return loss or maximum SWR (typically less than 2.0 or 1.5) over a frequency range conversion of bandwidth from one SWR level to another can be accomplished by using the relation between Bandwidth B and Q.

$$B = \frac{VSWR - 1}{Q\sqrt{VSWR}}$$

$$\%\ \text{impedance bandwidth} = \frac{fh - fl}{\sqrt{fhfl}}$$

3.8 Voltage Standing Wave Ratio (VSWR):

The standing wave ratio (SWR), also known as the voltage standing wave ratio (VSWR), is not strictly an antenna characteristic but is used to describe the performance of an antenna when attached to a transmission line. It is a measure of how well the antenna terminal impedance is matched to the characteristic impedance of the transmission line. Specifically, the VSWR is the ratio of the maximum to the minimum RF voltage along the transmission line. The maxima and minima along the lines are caused by partial reinforcement and cancellation of a forward-moving RF signal on the transmission line and its reflection from the antenna terminals. If the antenna terminal impedance exhibits no reactive (imaginary) part and the resistive (real) part is equal to the characteristic impedance of the transmission line, then the antenna and transmission line perfectly obeys impedance matching conditions .

$$\text{VSWR}=\frac{v_{maximum}}{v_{minimum}}$$

3.9 Polarization:

In general polarization of an antenna is referred to as, the orientation of radiation of that antenna. The polarization of an antenna in the given direction is defined as the polarization of the wave transmitted by the antenna. When the direction is not stated the polarization is taken to be polarization in direction of maximum gain. In practice polarization of the radiated energy varies with direction from the centre of the antenna so that different parts of the pattern may have different polarization. Polarization of radiated wave is defined as those properties of electromagnetic wave describing the time-varying direction and relative magnitude of electric field vector specifically the figure traced as a function of time by the extremity of the vector at a fixed location at in space and sense in which it is traced as observed along the direction of propagation. Polarization may be linear, circular or elliptical [16].

3.10 Input Impedance:

Input impedance is defined as “the impedance presented by an antenna at its terminals or the ratio of voltage to current at pair of terminals or the ratio of the appropriate component of the electric to magnetic fields at a point”. In this section, we are primarily interested in the input impedance at pair of terminals which are input terminals of the antenna.

$$ZA=RA+jXA$$

3.11 Front to back ratio:

It is the ratio of the power radiated in the desired direction to the power radiated in the opposite direction.

$$\text{FBR}=\frac{Power\ radiated\ in\ the\ desired\ direction}{Power\ radiated\ in\ opposite\ direction}$$

The front-to-back ratio value desired is very high as it is expected to have large radiation in the front or desired direction rather than that in the back or opposite direction. 15 The FBR depends on the frequency of operation. So when the frequency of an antenna changes, the FBR also changes. Similarly, the FBR depends on the spacing between the antenna elements. If the spacing between antenna elements increases the FBR decreases.

The FBR also depends on the electrical length of the parasitic elements of the antenna.

The FBR can be raised by diverting the gain of backward direction response of the antenna to the front or forward or desired direction by adjusting the length of the parasitic elements. The method of adjusting the electrical length of the parasitic element is called tuning. Thus higher FBR is obtained at the cost of gain from the opposite direction.

Practically the FBR is important in the case of the receiving antennas rather than transmitting antennas. At the receiving antenna, adjustments are made in such a way to obtain maximum FBR rather than maximum gain.

MONOPOLE ANTENNA

4.1 Introduction

Monopole antenna is one of the most popular types of wired antenna. These play a very significant role in today's wireless communication systems.Monopole is a type of the radio antenna formed by replacing one half of a dipole antenna with a ground plane at right angles to the remaining half. If the ground plane is large enough, the monopole behaves exactly like a dipole, as if its reflection in the ground plane formed the missing half of the dipole.

Mostly the monopole antennas are widely used in mobile and wireless communications because of their easycompatibility but this monopole antenna suffer due to theirlow BW. And lose of radiating energy which will affect its performance. So we use this structures to improvise its parameters and it is explained in ref. Now here we use pec material for the designed model is simulated by using HFSS software andthe simulated results are presented.

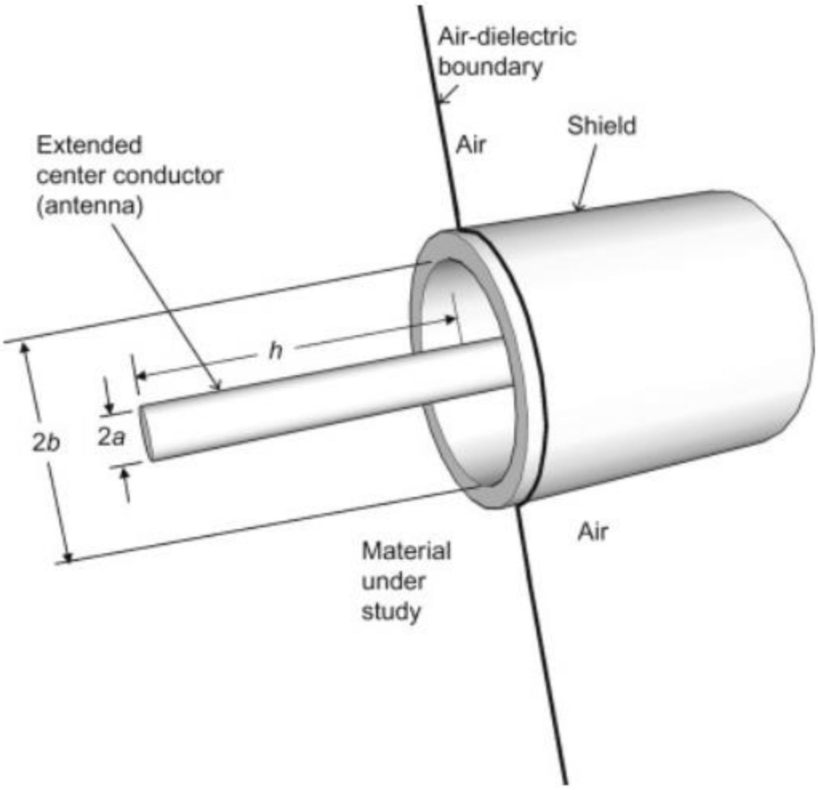
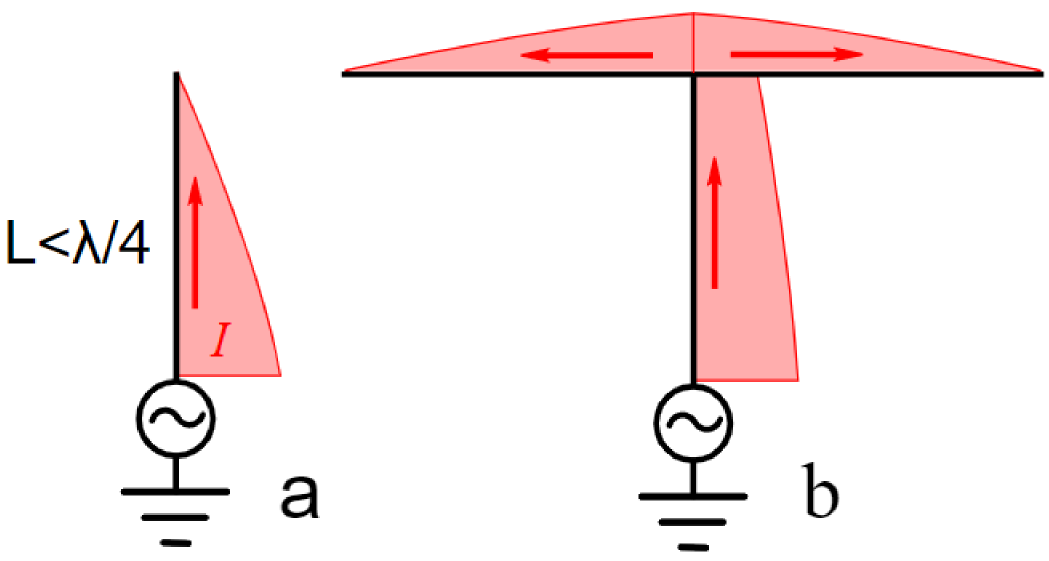


Fig4.1 :Monopole Antenna

Monopole antennas, as shown in Figure constitute a group of derivatives of dipole antennas. Here, only half of the dipole antenna is needed for operation. A metal ground plane (ideally of infinite size) is used, with respect to which the excitation voltage is applied to the half structure. The half structure for a regular dipole antenna is called a monopole antenna, in reference to the presence of only one physical side. A similar half structure for a folded dipole antenna is called a folded monopole antenna. The presence of the ground plane allows the monopole antenna to operate as electrically equivalent to a dipole antenna. The ground plane equivalently replaces the lower half by an imaging principle, similar to creating an optical image through a mirror. Notice in Figure that for the currents in the monopole and dipole structures to be the same, one needs the source voltage of the equivalent dipole antenna to be twice that of the monopole antenna.

The monopole is often used as resonant antenna; the rod functions as an open resonator for radio waves, oscillating with standing waves of voltage and current along its length. Therefore the length of the antenna is determined by the wavelength of the radio waves it is used with. The most common form is the *quarter-wave monopole*, in which the antenna is approximately one quarter of the wavelength of the radio waves. However in broadcasting monopole antennas 5/8 = 0.625 wavelength long are also popular, because at this length a monopole radiates a maximum amount of its power in horizontal directions. The monopole antenna was invented in 1895 by radio pioneer GUglielmo Marconi ; for this reason it is sometimes called the marconi antenna Common types of monopole antenna are thewhip,rubberducky,helical,random wire,umbrella inverted-L and T antenna,inverted F, mast radiator and ground plane antennas.

The load impedance of the quarter-wave monopole is half that of the dipole antenna or 37.5+j21.25 ohms.



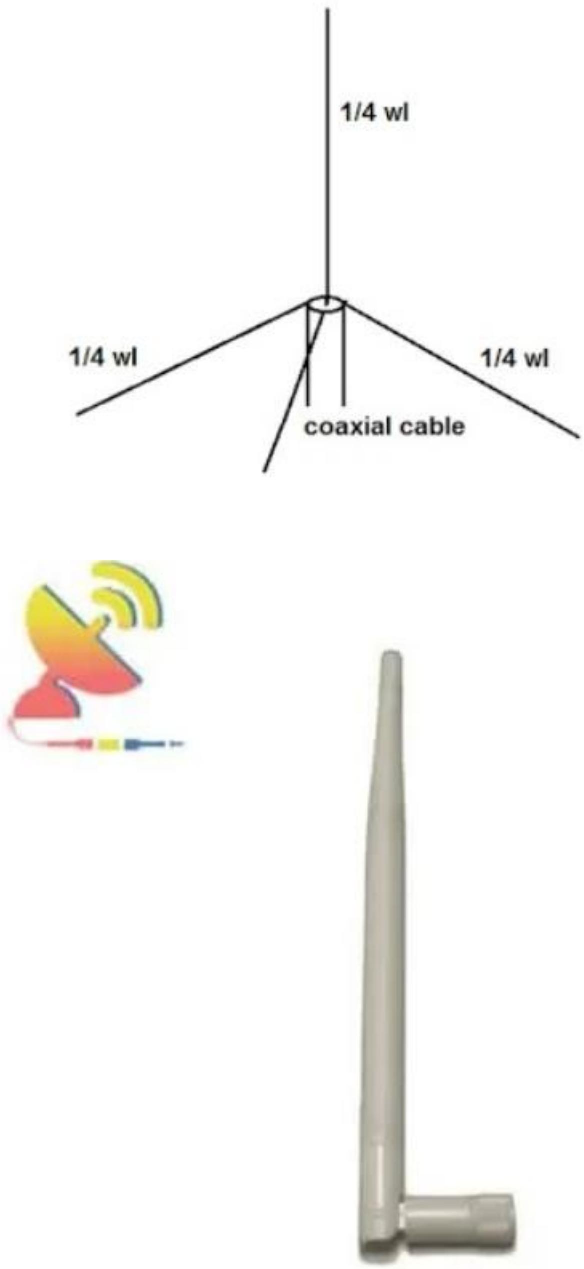


Fig 4.2: Different types of monopole antenna

4.2 Advantages and Disadvantages:

Mostly the monopole antennas are widely used in mobile and wireless communications because of their easycompatibility but this monopole antenna suffer due to theirlow BW. And lose of radiating energy which will affect its performance. So we use this structures to improvise its parameters and it is explained in ref. Now here we use pec material for the designed model is simulated by using HFSS software andthe simulated results are presented.

Some of the advantages of the microstrip patch antennas are given below:

1) Lightweight and low volume.

2)Low profile planar configuration which can be easily made conformal host surface.

3) Low fabrication cost, hence can be manufactured in large quantities.

4)Ease of manufacturing.

5)It has support for both linear and circular polarization.

6)Interior routing of cables which reduces wind loading.

7)Can be designed for multiple carriers plus micrewave capability.

8)Platforms and antenns arrrays can be rotated to any azimuth.

Monopole antennas suffer from several disadvantages as compared to conventional antennas. Some of their major disadvantages discussed below:

1) Narrow bandwidth.
2) Low efficiency.
3) Low Gain.
4) Extraneous radiation.
5) Low power handling capacity.
6) Surface wave excitation.

4.3 Design of circular patch antenna:

The design of monopole antenna is proposed in this section. The monopole antenna which is designed in rod shaped with the ground plane. The monopole is created using the material called pec.

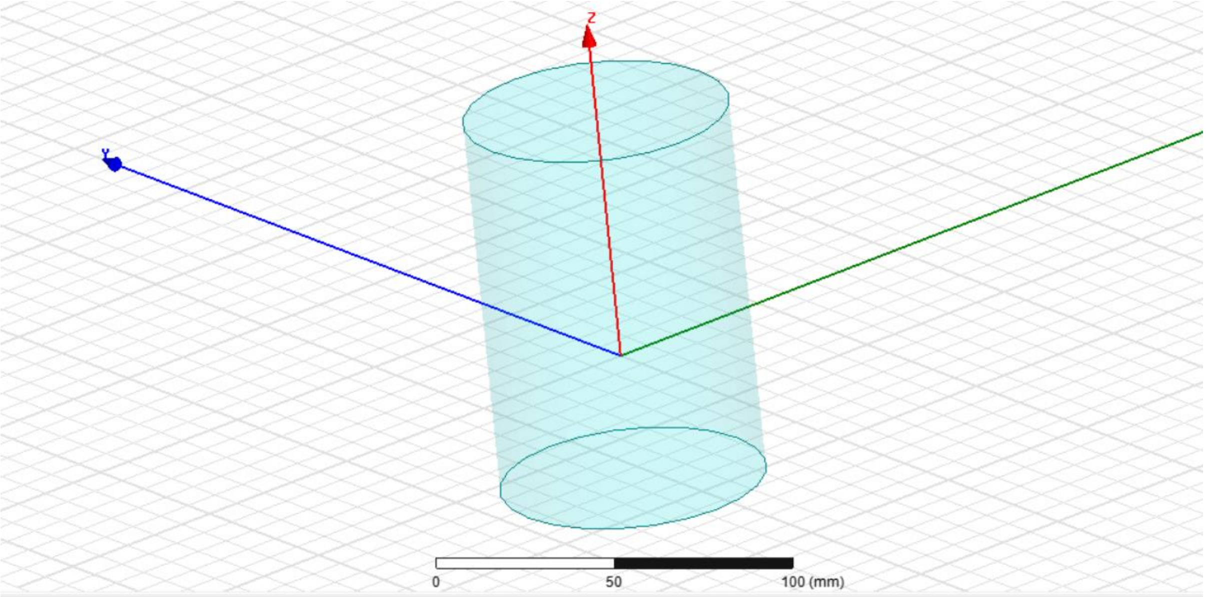


Fig 4.3: Air Box Suroounded Monopole Antenna

The monopole antenna which is designed in rod shaped. The radius and height of the dipole is 0.000625mm and 0.03625mm. The dipole is created using the material called pec.

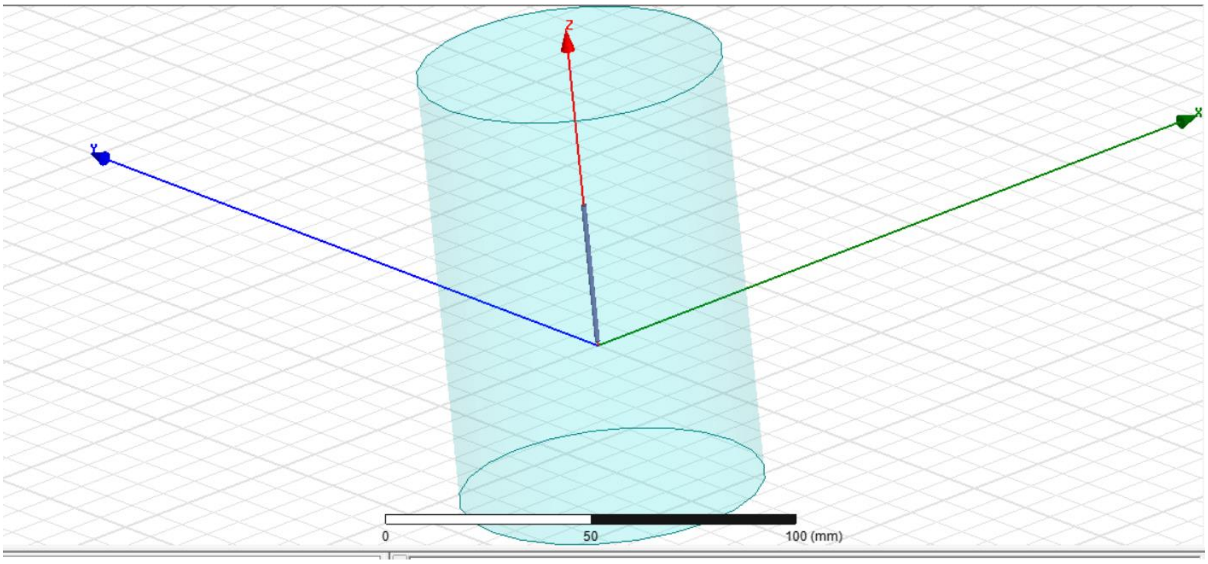


Fig 4.4: Air Box with Single end monopole antenna

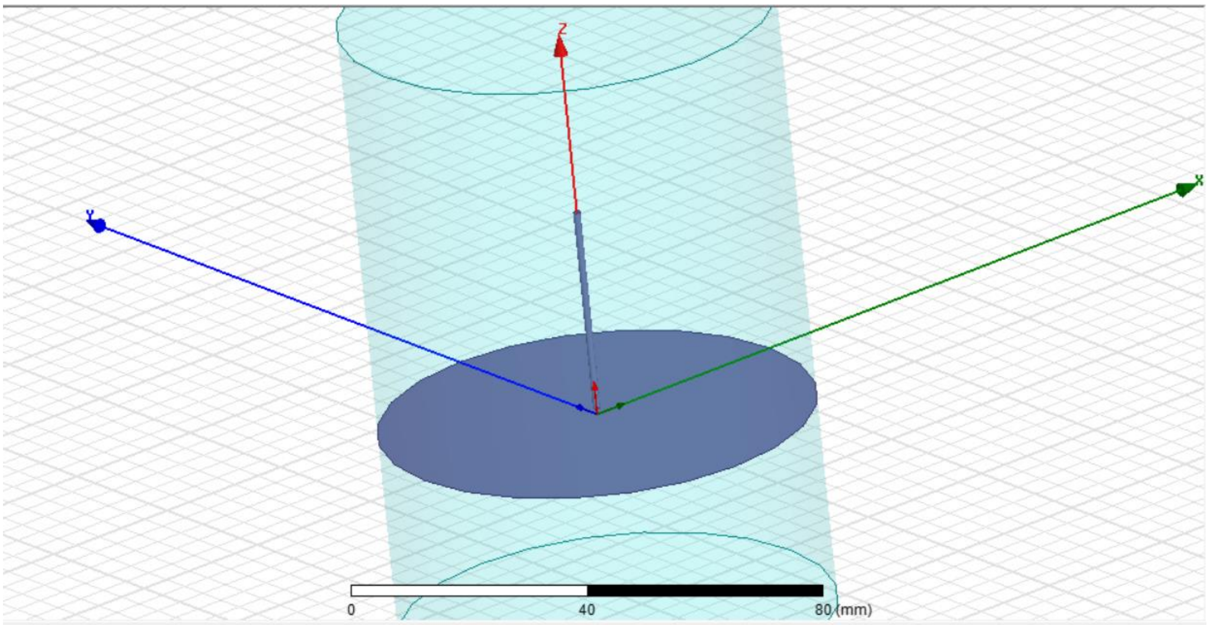


Fig 4.5: Air Box with monopole antenna with ground plane

Wavelength is calculated by using the below formula,

$\lambda = c / f$ where, c= 3×10^8 ….speed of the light

f= frequency (1)

Radius of the monopole antenn is calculated by using the formula given below,

$r = (\lambda / 4) / 60$ (2)

Feeding Gap of an antenna is calculated by using the below formula,

$g = r \times 2$ (3)

Length of the monopole is calculated by using below formula,

$l = (\lambda / 4) - g$ (4)

Between the two cylindrical half wave dipole, a thin rectangular slab is to be inserted for establishing the connection between the rod and the ground plane. The rectangular sheet is to be placed in the YZ axis.

The rectangular cylindrical sheet is to be projected accurately at the center of the two three dimensional rod shaped And the ground plane. The whole dipoless are to be covered with the cylindrical shaped airbox which prevents the radiation to get lossed in unwanted direction.

Parameters of Monopole Antenna	**Values**	**Units**
Frequency(f)	2	GHz
Wavelength(λ)	0.14	mm
Radius(r)	0.0060	mm
Feeding Gap(g)	0.00120	mm
Length of the antenna(l)	0.0362	mm

Table 1: Parameters of Monopole Antena

DIPOLE ANTENNA

5.1 INTRODUCTION

The dipole antenna is the most efficient class of antenna in radio and telecommunication field. The dipole antenna whose radiation pattern produced is approximately equal to a radiating structure which is having an elementary structure [1].

In dipole antenna, feed line is connected between the two conductors of equal length providing end to end connection. Dipole antennas are highly preferred to act as resonant antennas. Feed point plays a vital role in this kind of antenna. When the feed point is shorted, then the antenna is able to resonate at a particularfrequency. E.g. Guitar. It is very useful for operating the antenna at particular frequency in terms of feed pointimpedance. Hence, the length of the feed point decides the frequency of operation. Out of these all, the use of center-fed-half-wave dipole is literally high [2].

The dipole antenna act as omni directional when it is installed vertically and act like weekly directional antenna when it is installed horizontally. Nowadays, most of the antennas used is to be seen as based on the dipole. Many directional antennas like horn, parabolic, reflector is feed by dipole antennas. It is already analyzed that vertical antennas on the base of dipole antenna design which is half of vertical antenna.5.2

5.2 TYPES OF DIPOLE ANTENNA

In normal applications, shorter dipoles are used frequently and preferred where full half-wave dipole is larger in size [3]. The Hertzian dipoles are used to analyze this kind of antenna. Though these dipole antennae are shorter than a resonant antenna, the feed point impedance of dipole antenna includes a capacitive reactance which is chose to be very large in order to be practical and is used especially as a type of transmitting antenna.

5.2.1DIPOLE ANTENNA OF DIFFERENT LENGTH

The resonance for a kind of a thin linear conductor will be occurring at a frequency whose wire length will be equal to half of wavelength. These kind of dipole antennas are used around that particular frequency and hence it is called as half-wave dipole antennas [4]. Dipoles with half-wavelengths in length and odd number values are used to havelow driving point impedances. Due to half-wavelength in length with even number values, the diploes are having huge driving point impedances [5,6].

5.2.2 HALF WAVE DIPOLE ANTENNA

In conductors which are placed end to end to get a length and with the combined two quarter-wavelength diploes are roughly equal to half wavelength which forms the half-wave dipole antenna[7]. The current whose magnitude in a standing wave along the dipole and the electric field of half-wave dipole transmitting antenna are show in the below figure.

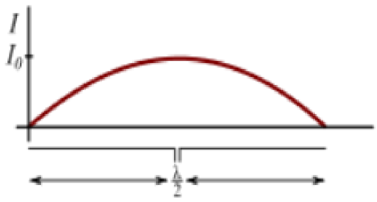


Fig 5.1: Standing Wave - magnitude of current waveform

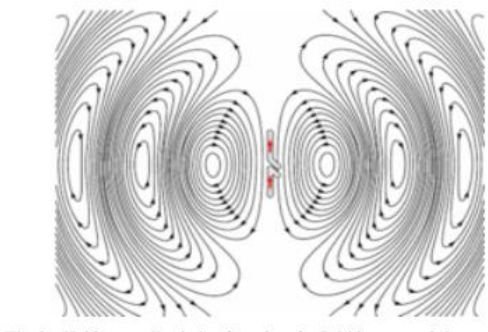


Fig 5.2: Half wave dipole having electric field in transmitting antenna

In general, the current (I) is distributed in the form of standing waves in which the sinusoidal is along the length of the dipole. It is having nodes at each end and antinodes at the center called feed point.

5.3 CHARACTERISTICS OF DIPOLE ANTENNA

5.3.1 IMPEDENCE OF VARIOUS LENGTH

The impedance of feed point of a dipole antenna is sensitive to both of its electrical length and feed point position. Hence, a dipole will perform over rather narrow bandwidth [8,9]. When it exceeds beyond this bandwidth the impedance will match poorly to the transmitter or receiver. The smaller dipole with small wavelength of the signal is called as short dipole. These diploes are having low level of radiation resistance which insist them to be asineffective antennas [10]. The Transmitter current is mostly dissipated owing to the resistance of the conductor which is greater than the Heat - radiation resistance [11].

5.3.2 RADIATION PATTERN AND GAIN

A dipole with the radiation falls to zero on the axis is perpendicular to the wire axis. The radiation pattern of 3D dipole is plotted approximately as a toroid symmetric about the conductor in the half wave dipole. If the antenna is mounted vertically it will result in maximum radiation in horizontal directions [12].

In this case when the antenna is mounted horizontally, the radiation value reaches the peak value and null value at right angles and in the direction of the dipole.

5.4 Design of Dipole Antenna:

The design of dipole antenna is proposed in this section. Generally, a dipole antenna consists of two conductors which are half waved dipole. The designed antenna is to be surrounded with the air box which is cylindrical in shape. The radius and height of the dipole is 0.00125 and 0.0325mm.

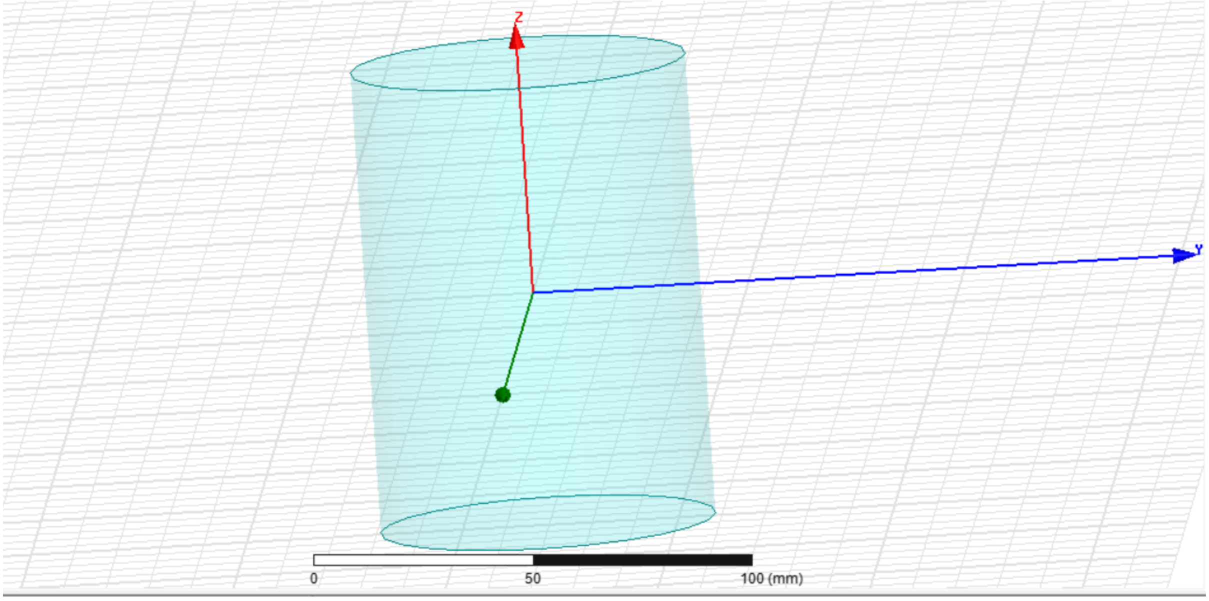


Fig 5.3: Air Box Surrounded Dipole Antenna

The dipole antenna which is designed in rod shaped. The radius and height of the dipole is 0.0025mm and 0.065mm. The dipole is created using the material called pec.

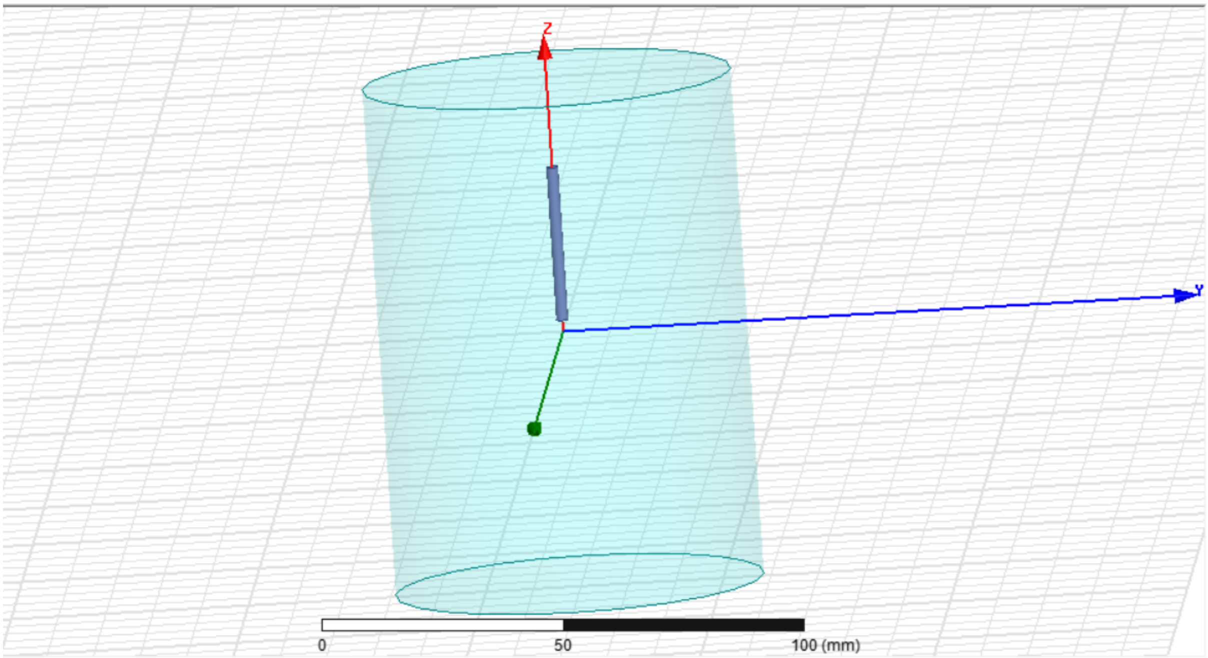


Fig 5.4 : Air Box with Single End Dipole Antenna

The dipole antenna having two half waved dipole is to be illustrated using the below shown figure.

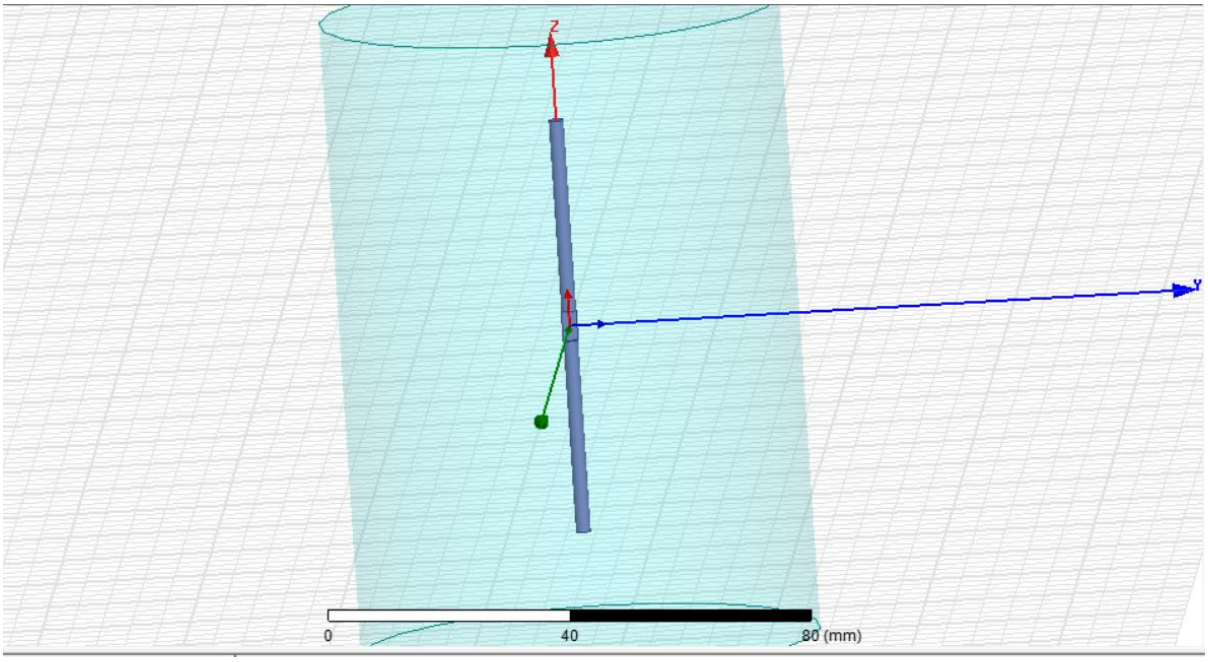


Fig 5.5: Dipole with Rectangular Conducting Interface

Between the two cylindrical half wave dipole, a thin rectangular slab is to be inserted for establishing the connection between the two half wave dipoles. The rectangular sheet is to be placed in the YZ axis.

Wavelength,

$\lambda = c / f$ where, c $= 3 \times 10$^8 …..speed of the light (5)

f=frequency

Radius of the Dipole antenna is calculated by using the below formula,

$r = (\lambda / 2) / 60$ (6)

Feeding Gap of an antenna is calculated by using the below formula,

$g = r \times 4$ (7)

Length of the Dipole antenna is calculated by using the below formula,

$$l = (\lambda / 4) - g \qquad (8)$$

Parameters of Dipole Antenna	Value	Units
Resonant frequency(f)	2	GHz
Wavelength(λ)	0.3	mm
Radius(r)	0.0025	mm
Feeding Gap(g)	0.01	mm
Length of the antenna(l)	0.065	mm

Table 2: Parameters of Dipole Antenna

The rectangular cylindrical sheet is to be projected accurately at the center of the two three dimensional rod shaped dipoles. The whole dipoles are to be covered with the cylindrical shaped airbox which prevents the radiation to get lossed in unwanted direction.

5.5 ADVANTAGES AND DISADVANTAGES OF DIPOLE ANTENNA:

The following are the advantages of using monopole antenna:

1) The signal strength increases
2) The high directivity is obtained
3) Minor lobes are reduced much
4) High Signal-to-noise ratio is achieved

5) High gain is obtained

6) Power wastage is reduced

7) Better performance is obtained

The following are the disadvantages of array antennas:

1) Resistive losses are increased

2) Mounting and maintenance is difficult

3) Huge external space is required

5.6 APPLICATIONS :

1)Wireless communications

2)radio and telecommunications

3)VHF FM broadcast antennas

DESIGN OF MONOPOLE AND DIPOLE ANTENNA USING HFSS

HFSS is a commercial method solver for electromagnetic structures fromAnsys Corp.

HFSS stands for High Frequency Structure Simulator. It is one ofthe several commercial tools used for antenna design. It was developed by Prof.Zontal Cendes and his students at Carnegie Mellon University in the year Its gold-standard accuracy, advanced solver a compute technology have made it an essential tool for engineers designing high-frequency and high-speed electronic components. HFSS is an interactive simulation

system whose basic mesh element is a tetrahedron. This allows you to solve any arbitrary 3D geometry, especially those with complex curves and shapes and shapes, in a fraction of the time it would take using other techniques. HFSS has evolved over years with input from many users and industries. In industry, Ansoft HFSS is the tool of choice for High productivity research, development, and virtual prototyping.

6.1 Getting Started with HFSS:

1. Create the New Project:

• Click File => New

• A new project is listed in the project tree in the project manager window.

2. Inserting an HFSS Design:

• Click Project => Insert HFSS Design or Insert HFSS-IE Design or Insert HFSSIE Design.

• The new design is listed in the project tree. It is named as HFSS Design. • The 3D Modeler window appears to the right of the Project Manager.

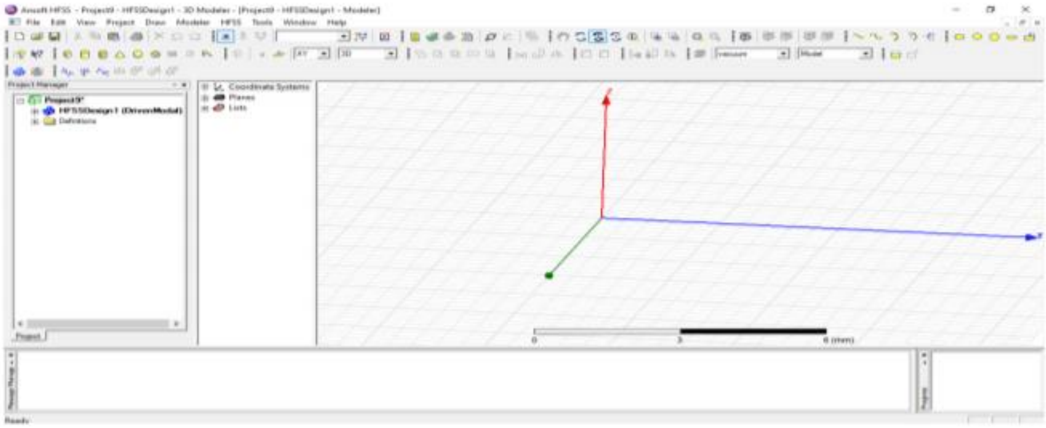


Fig 6.1 :HFSS 3D Modeler window

3. Selecting the Solution Type:

- Click HFSS > Solution Type. The solution type dialog box appears.

- Select any one of the following solution types.

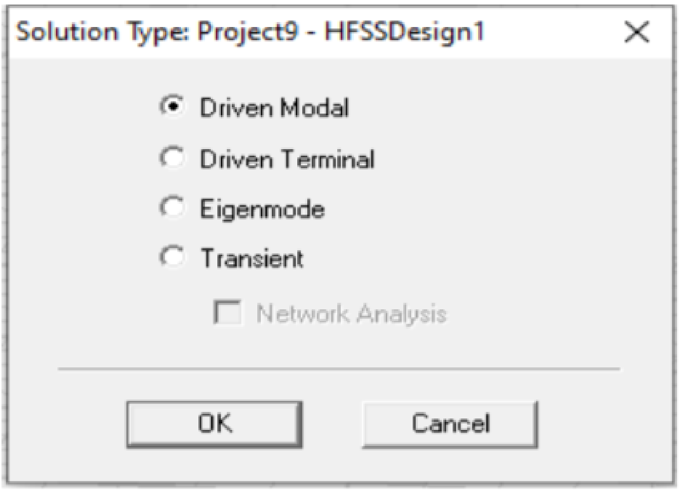


Fig 6.2 Window for selecting solution type

4. Assigning Materials:

- You can add, remove, and edit materials in two main ways:

a. Using the Tools => Edit configured Libraries => Materials menu command.

b. Right-clicking Materials in the project tree and selecting edit all libraries.

• To assign a material to an object, follow this general procedure:

a. Select the object to which you want to assign a material.

b. Click Modeler => Assign material

5. Assigning Boundaries:

• Right-click on the object => Assign boundary

• Select any one of the following

a. PerfectE:Represents a perfectly conducting surface. This resembles the HFSS perfect E Boundary but does offer to select an infinite ground plane

b. Finite Conductivity: Represents an imperfect conductor

c. Infinite Ground Plane: Represents the effects of an infinite ground plane d. Aperture: Represents holes in the design

e.Impedance: Represents a resistive surface

f. Lumped RLC: Represents any combination of lumped resistor, inductor, and or capacitor in parallel on a surface.

g. Layered Impedance: Represents a structure with multiple layers as one impedance surface.

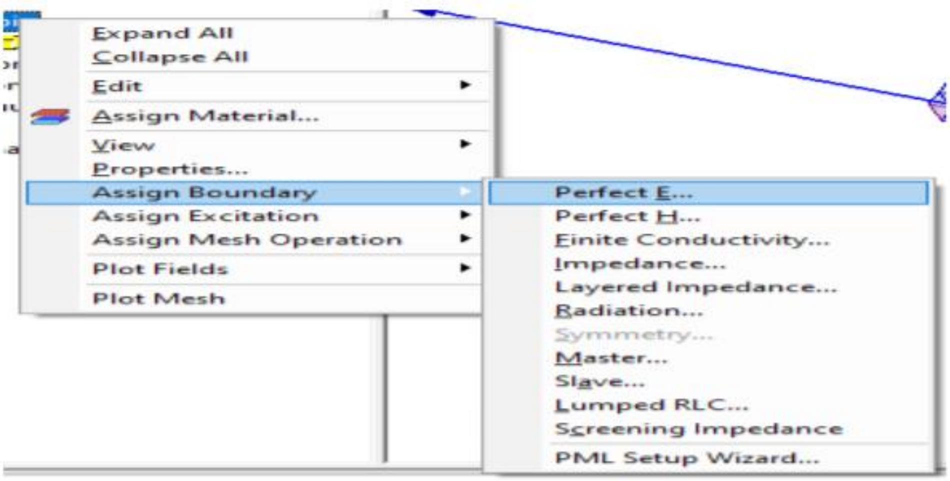


Fig 6.3 Window for Assigning Boundaries

6.Creating a Monopole antenna:

• Create a cylinder by clicking on the toolbar and selecting a cylinder shape, then click on the object => create cylinder => edit the values.

• Create a ground by clicking on the toolbar and select a circle, then click on the object => create circle as a ground => edit the values.

• Create a another cylinder by clicking on the toolbar and select a cylindrical shape as the air box, then click on the object => create box => edit the values.

• Create a rectangle as the interface in between the cylinder and the ground plane by clicking on the toolbar and select a rectangle, then click on the object => create rectangle => edit the values.

7. Creating a Dipole antenna:

• Create a cylinder by clicking on the toolbar and selecting a cylinder shape, then click on the object => create cylinder => edit the values.

• Create a another by clicking on the toolbar merge option and select a optiom then click on the object => create another cylinder in opposite manner=> edit the values.

• Create a cylinder by clicking on the toolbar and select a cylindrical shape as the air box, then click on the object => create box => edit the values.

• Create a rectangle as interface between the two cylinders by clicking on the toolbar and select a rectangle, then click on the object => create rectangle=> edit the values.

8. Assigning Lumped port:

• To create a lumped port creates a rectangle that represents the source port.

• To assign the lumped port excitation select the object(source port) and right click on it => Assign excitation => Lumped port => click on next => Integration line => new line => click on next

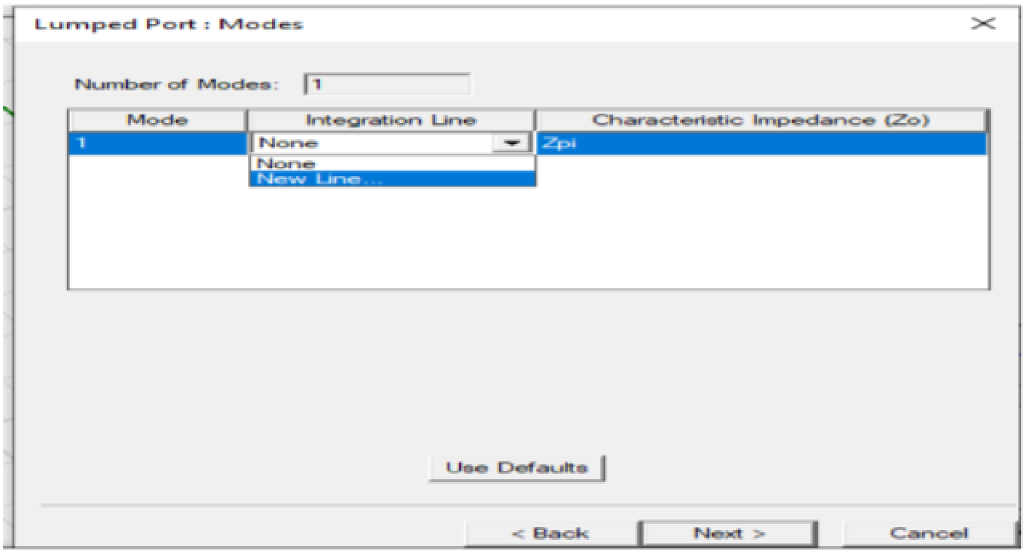


Fig 6.4 Window for defining lumped port

9. **Analysis setup:**

• Select the menu item HFSS => Analysis setup => Add Solution setup.

• In the Solution Setup window, click the general tab, solution frequency is 2GHz, the maximum number of passes is 20.

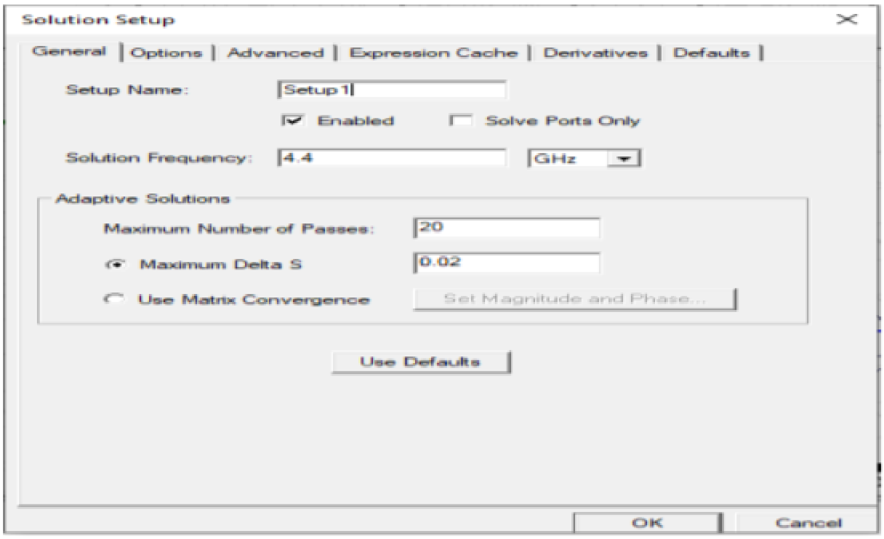


Fig 6.5: Analysis setup window

10. **Adding Frequency Sweep:**

• To add a frequency sweep, select the menu item HFSS => Analysis setup => Add sweep.

• Select Solution setup => Setup1 => click ok button. Then edit sweep window. a. Sweep type :Fast

b. Frequency setup type : Linear count

c. Start : 1GHz d. Stop : 2.5GHz

C. Count :200 Click OK button

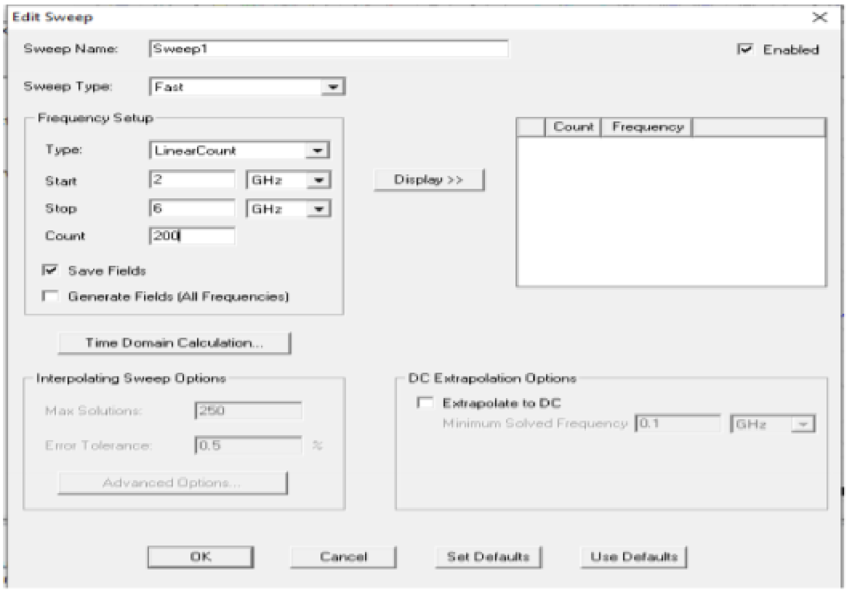


Fig 6.6 Window for adding frequency sweep

12.Save project:

• To save the project:

a. In an Ansoft HFSS window, select the menu item file => save as.

b. From the save as window, type the filename

c. Click the save button 11. Analyze the design:

• Modal Validation: To validate the modal:

a. Select the menu item HFSS => Validation Check

b. Click the Close button Note: To view any errors or warning messages, use the message manager.

• Analyze: To start the solution process: a. Select the menu item HFSS => Analyze All The simulation will stop as soon as the results coverage, which is at pass 10.

13. Create Report:

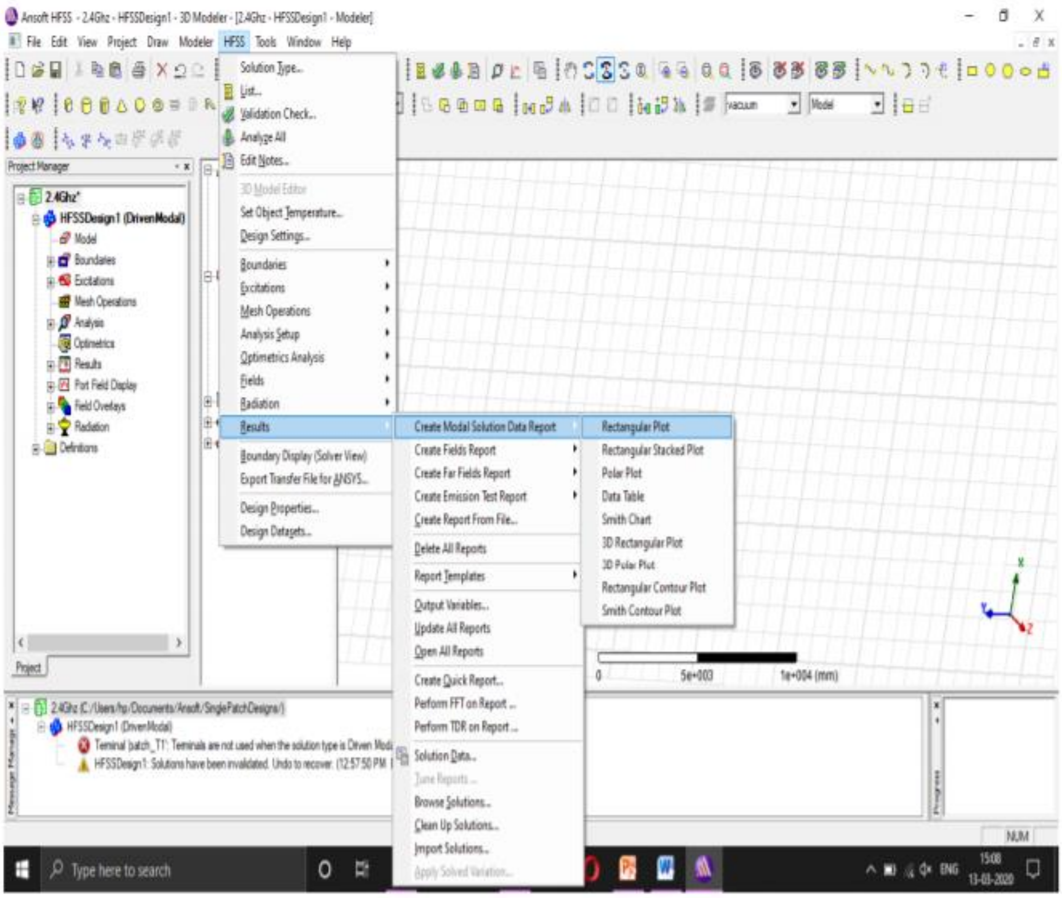


Fig6.7 Window for creating a report

• Return loss report:

a. Select the menu HFSS => results => Create modal solution data report => rectangular plot, then a new window opens.

b. In that Window select category as S-parameter and function as dB. Then the return loss plot will be displayed.

•Impedance Plot:

a. Select the menu HFSS => results => Create modal solution data report => rectangular plot, then a new window opens.

b. In that Window select category as S parameters and Zparameters as dB. Then theplot will be displayed.

• **Radiation Pattern:**

a. Select the menu HFSS => results => Create far field report => radiation pattern, then a new window opens.

b. In that Window select category as gain and function as dB. Then the radiation pattern will be displayed.

• **3D Polar plot:**

a. Select the menu HFSS => results => Create far-field report => 3D polar plot, then a new window opens.

b. In that Window select category as gain and function as dB. Then the radiation pattern will be displayed.

6.2 Simulation results:

The proposed antenna arrays are designed and simulated in HFSS software version v13.0. The designed antennas are analyzed in terms of gain, return loss, VSWR and radiation pattern.

6.2.1 Return loss plot:

Figure.6.8 and 6.9 Shows return loss [S_{11}] of the proposed monopole and dipole antennas in dB. The plot gives the return loss at the feed position where the antennainputwas applied. It should be lower than -10 dB for acceptable operation. The monopole antenna design produce -16.88 dBreturn losswhereas dipole antenna design produce -20.11dBreturn loss.

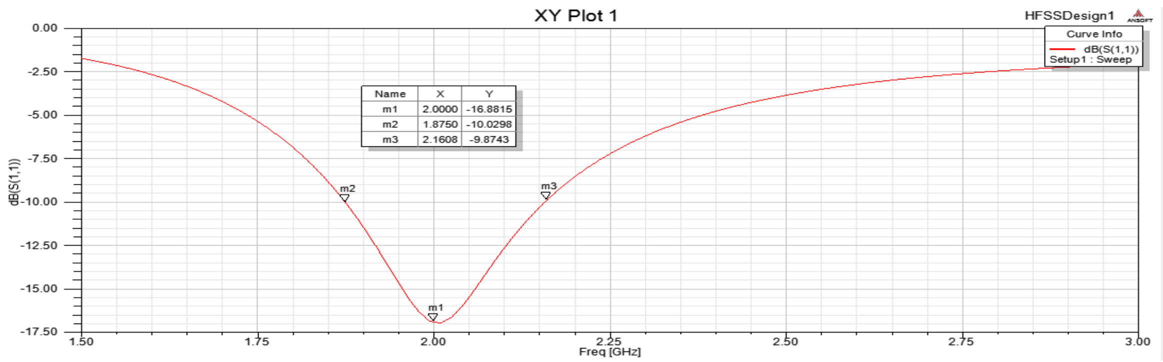


Fig.6.8.Return loss plot of Monopole Antenna

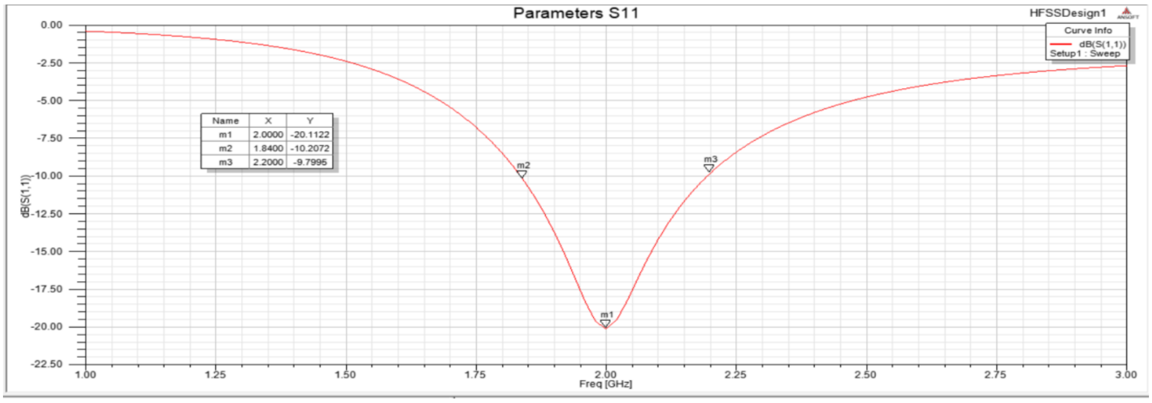


Fig.6.9.Return loss plot of Dipole Antenna

Directivity is one of the important parameters of the antenna and is defined as the measure if degree at which the radiation of the antenna tends to be projected on single direction. Generally, the directivity of the antenna is to be 2dB. The directivity gain of dipole antenna and monopole antenna

6.2.2 Impedance Plot:

Fig.6.10 and 6..11 Shows the impedance plot of monopole and dipole antennas in dB.

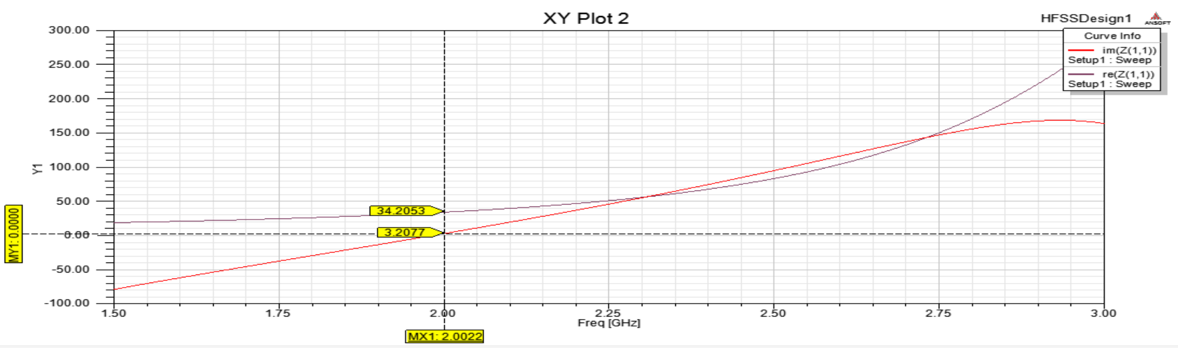


Fig.6.10.Impedance plot of Monopole Antenna

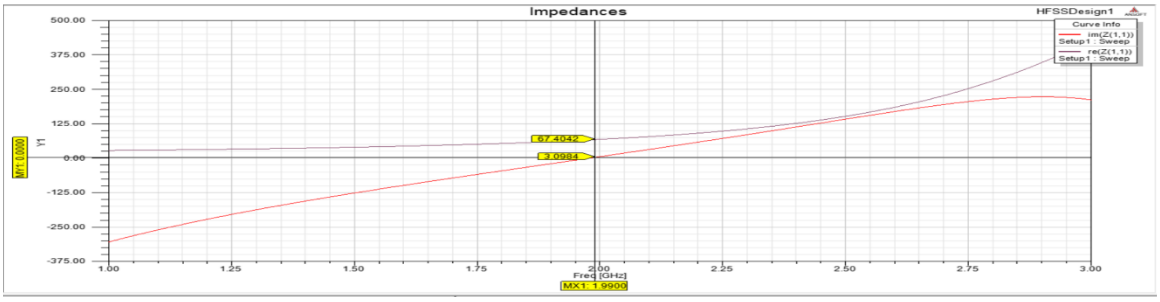


Fig.6.10.Impedance plot of Dipole Antenna

6.2.3 Radiation pattern:

Fig.6.11 and 6.12 shows the 2D radiation patterns of monopole and dipole antennas.

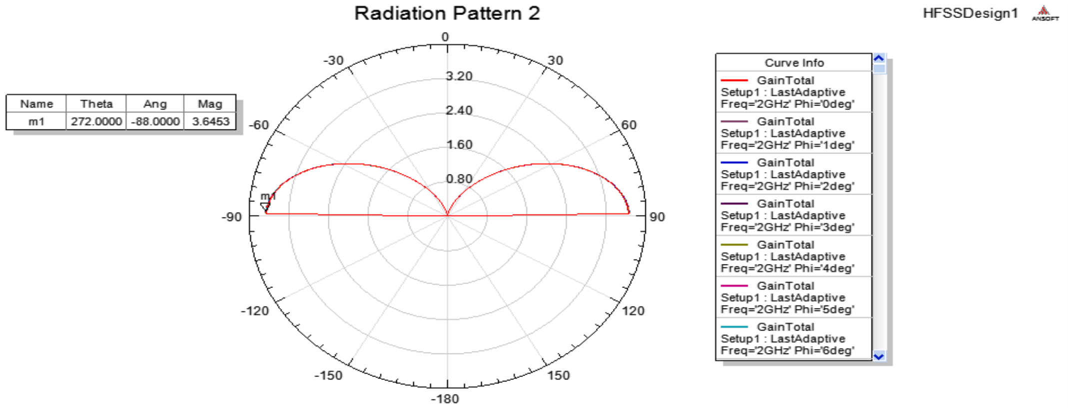


Fig.6.11 radiation pattern of Monopole Antenna

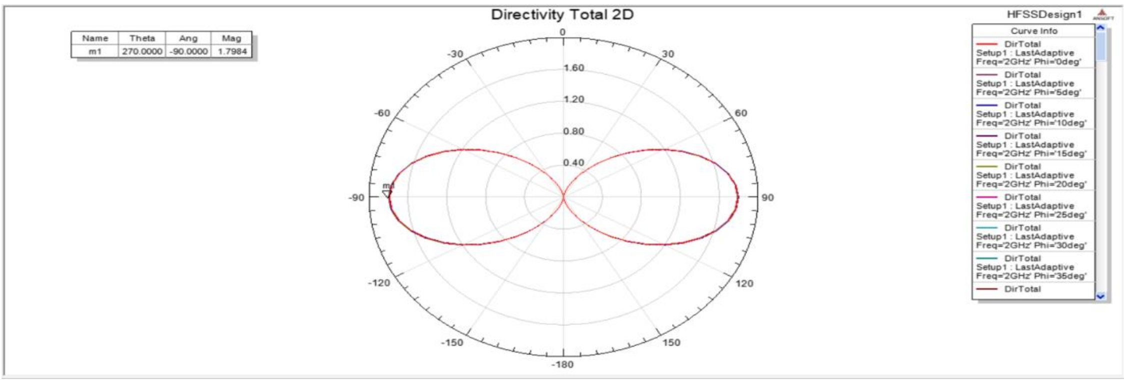


Fig.6.12 radiation pattern of Dipole Antenna

6.2.4 3D polar plot:

shows the 3D polar plots of monopole and dipole antennas.

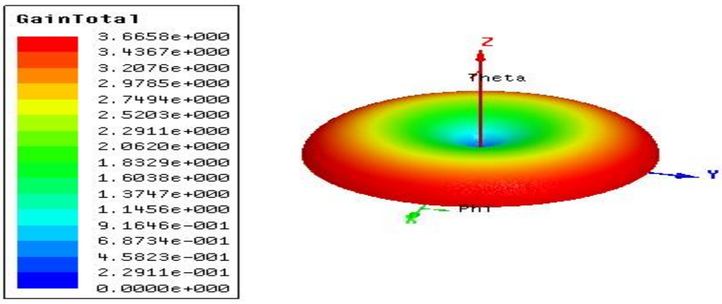


Fig.6.13 3D polar plot of Monopole Antenna

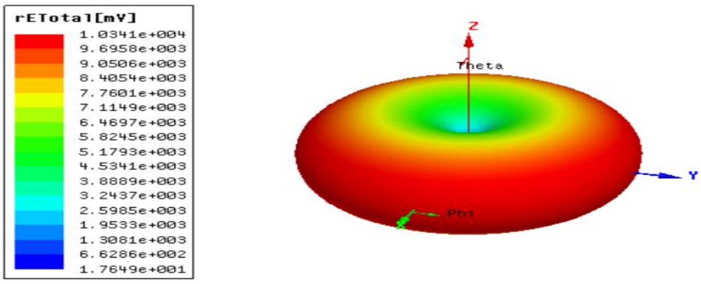


Fig.6.14 3D polar plot of Dipole Antenna

CONCLUSION

The monopole and dipole antennas are designed using High Frequency Structure simulator software.Resonant frequency for the antennas was taken at2GHz operating frequency,which is suitable for wireless communication,radio and telecommunication.. It has been found that the monopole antenna shows -16.88dB return loss, 6.99 Q factor, while the dipole antenna shows -20.11 dB return loss, 5.55 Q factor, and front-to-back ratio of 1.0037.The impedance, directivity, gainand the far field radiation patterns of resultant antennas have been observed.

Table 3: Comparison parameters of the monopole and dipole Antenna

PARAMETERS	**MONOPOLE ANTENNA**	**DIPOLE ANTENNA**
Frequency(f)	2	2
Max U(W/sr)	0.28579	0.14182
Peak Directivity	3.6723	1.8019
Peak Gain	3.6658	1.7998
Peak Realised Gain	3.5915	1.7923
Radiated Power(W)	0.978	0.98912
Accepted Power(W)	0.97972	0.99026
Incident Power(W)	1	1
Radiation Efficiency	**0.99825**	**0.99885**
Decay Factor	0	0
Front to back ratio	-N/A	1.00037
Quality factor	6.99	5.55
%Bandwidth	14.163%	17.821%

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