Performance Analysis of dipole antenna & patch antenna around 2.4GHZ

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Declaration

This report on the basis of our thesis paper and its enhancement of studies throughout our thesis work is submitted to follow the terms and conditions of the department of Electronics and Communications Engineering .This report is the requirement for the successive competition of B.Sc. Engineering in Electronics and Communications Engineering.

We state that the report along with its literature that has been demonstrated in this report papers, is our own work with the masterly guidance and fruitful assistance of our supervisor for the finalization of our report successfully.

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Approval

The project title “Performance Analysis of dipole antenna & patch antenna around 2.4GHZ” submitted by Mamunur Rashid Shawon [ID: 2013-2-55-032], Sharmin Aktar [ID: 2014-1-55-017] in the semester of Fall-2017 is approved satisfactory in partial fulfillment of the requirements for the degree of Bachelor of Science in Electronics and Telecommunication Engineering.

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Acknowledgment

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Abstract

The research work that is to be presented is based on the study and designing of antenna system for wireless RF energy harvesting for domestic or indoor environments. An introduction to the essential prerequisites have been presented prior to the work along with the literature survey that went in and thus, the main research work was presented along with the different tests and the various results from both simulations as well as results.

The main research work is divided into two parts.

- The 1st part describes about the design and analysis of the antennas.
- The 2nd part describes about the results as well as efficiency of the antennas in real world.

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Chapter 1

INTRODUCTION

Technology plays an important role in our daily life. Different devices and transducer plays different in technology. An antenna radiation pattern or antenna pattern is defined as a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates. [1] An antenna is a specialized transducer that converts radio-frequency (RF) fields into alternating current (AC) or vice-versa. There are two basic types: the receiving antenna, which intercepts RF energy and delivers AC to electronic equipment, and the transmitting antenna, which is fed with AC from electronic equipment and generates an RF field. In computer and Internet wireless applications, the most common type of antenna is the dish antenna used for satellite communications. Dish antennas are generally practical only at microwave wave frequencies (above approximately 3 GHz). The dish consists of a paraboloidal or spherical reflector with an active element at its focus. When used for receiving, the dish collects RF from a distant source and focuses it at the active element. When used for transmitting, the active element radiates RF that is collimated by the reflector for delivery in a specific direction. An antenna is an electrical conductor or system of conductors.

The IEEE definition of an antenna as given by Stutzman and Thiele is, “That part of a transmitting or receiving system that is designed to radiate or receive electromagnetic waves”. [2]

1.1 Antenna Parameters

1.1.1 Gain

Gain is a measure of the ability of the antenna to direct the input power into radiation in a particular direction and is measured at the peak radiation intensity. Consider the power density radiated by an isotropic antenna with input power P_0 at a distance R which is given by $S = P_0/4\pi R^2$. An isotropic antenna radiates equally in all directions, and its radiated power density S is found by dividing the radiated power by the area of the sphere $4\pi R^2$. An isotropic radiator is considered to be 100% efficient. The gain of an actual antenna increases the power density in the direction of the peak radiation:

$$S = \frac{P_0 G}{4\pi R^2} = \frac{|E|^2}{\eta} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.(1)$$

Gain is achieved by directing the radiation away from other parts of the radiation sphere. In general, gain is defined as the gain-biased pattern of the antenna. [2]

1.1.2 Antenna Efficiency

The surface integral of the radiation intensity over the radiation sphere divided by the input power P_0 is a measure of the relative power radiated by the antenna, or the antenna efficiency.

$$\frac{P_r}{P_0} = \int_0^{2\pi} \int_0^{\pi} \frac{G(\theta,\emptyset)}{4\pi} sin\theta d\theta d\emptyset = \eta_e \dots\dots\dots..(2)$$

where P_r is the radiated power. Material losses in the antenna or reflected power due to poor impedance match reduce the radiated power. [2]

1.1.3 Input Impedance

The input impedance of an antenna is defined as "the impedance presented by an antenna at its terminals or the ratio of the voltage to the current at the pair of terminals or the ratio of the appropriate components of the electric to magnetic fields at a point". Hence the impedance of the antenna can be written as given below.

$$Z_{in} = R_{in} + jX_{in} \dots\dots\dots\dots\dots\dots\dots\dots..(3)$$

where Z_{in} is the antenna impedance at the terminals

R_{in} is the antenna resistance at the terminals

X_{in} is the antenna reactance at the terminals

The imaginary part, X_{in} of the input impedance represents the power stored in the near field of the antenna. The resistive part, R_{in} of the input impedance consists of two components, the radiation resistance R_r and the loss resistance R_L. The power associated with the radiation resistance is the power actually radiated by the antenna, while the power dissipated in the loss resistance is lost as heat in the antenna itself due to dielectric or conducting losses. [2]

1.2 Some Future Challenges

Antenna engineering has enjoyed a very successful period during the 1940s–1990s. Responsible for its success have been the introduction and technological advances of some new elements of radiation, such as aperture antennas, reflectors, frequency independent antennas, and microstrip antennas. Excitement has been created by the advancement of the low-frequency and high-frequency asymptotic methods, which has been instrumental in analyzing many previously intractable problems. Amajor factor in the success of antenna technology has been the advances in computer architecture and numerical computation methods. Today antenna engineering is considered a truly fine engineering art. Although a certain level of maturity has been attained, there are many challenging opportunities and problems to be solved. Phased array architecture integrating monolithic MIC technology is still a most challenging problem. Integration of new materials, such as metamaterials, artificial magnetic conductors and soft/hard surfaces, into antenna technology offers many opportunities, and asymptotic methods will play key roles in their incorporation and system performance. Computational electromagnetics using supercomputing and parallel computing capabilities will model complex electromagnetic wave interactions, in both the frequency and time domains. Innovative antenna designs such as those using smart antennas, and multifunction, reconfigurable antennas and antenna systems , to perform complex and demanding system functions remain a challenge. New basic elements are always welcome and offer refreshing opportunities. New applications include, but are not limited to wireless communications, direct broadcast satellite systems, global positioning satellites (GPS), high-accuracy airborne navigation, global weather, earth resource systems, and others. Because of the many new applications, the lower portion of the EM spectrum has been saturated and the designs have been pushed to higher frequencies, including the millimeter wave frequency bands.[1]

1.3 Types of antenna

1.3.1 Wire Antennas

Wire antennas are familiar to the layman because they are seen virtually everywhere on automobiles, buildings, ships, aircraft, spacecraft, and so on. There are various shapes of wire antennas such as a straight wire (dipole), loop, and helix. Loop antennas need not only be circular. They may take the form of a rectangle, square, ellipse, or any other configuration. The circular loop is the most common because of its simplicity in construction.

1.3.2 Loop Antennas

A loop of wire, with many turns, is used to radiate or receive electromagnetic energy.

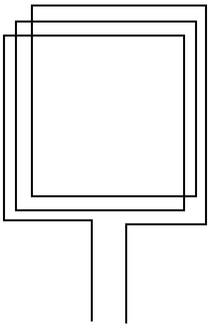

Figure1.1: Loop Antenna [3]

1.3.3 Aperture Antennas

Aperture antennas may be more familiar to the layman today than in the past because of the increasing demand for more sophisticated forms of antennas and the utilization of higher frequencies. Antennas of this type are very useful for aircraft and spacecraft applications, because they can be very conveniently flush-mounted on the skin of the aircraft or spacecraft. In addition, they can be covered with a dielectric material to protect them from hazardous conditions of the environment.

1.3.4 Dipole Antenna

The dipole is one of the most common antennas. It consists of a straight conductor excited by a voltage from a transmission line or a waveguide. Dipoles are easy to make.

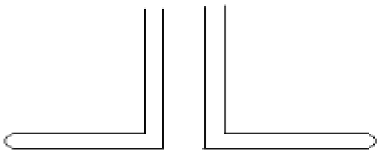

Figure1.2: Dipole Antenna [3]

1.3.5 Reflector Antennas

The parabolic reflector is a good example of reflectors at microwave frequencies. In the past, parabolic reflectors were used mainly in space applications but today they are very popular and are used by almost everyone who wishes to receive the large number of television channels transmitted all over the globe.

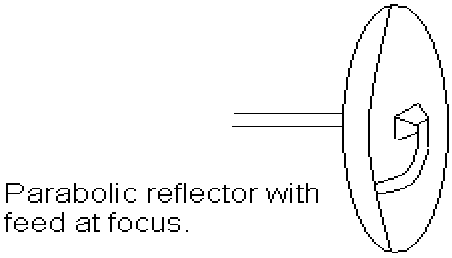

Figure1.3: Reflector Antenna[3]

1.3.6 Array Antennas

Many applications require radiation characteristics that may not be achievable by a single element. It may, however, be possible that an aggregate of radiating elements in an electrical and geometrical arrangement (an array) will result in the desired radiation characteristics. The arrangement of the array may be such that the radiation from the elements adds up to give a radiation maximum in a particular direction or directions, minimum in others, or otherwise as desired.

1.4 Advantages [4]

Following are the advantages of Antenna types:

- Dipole Antenna: They are cheap and exhibits good gain.
- Whip Antenna: It delivers good performance with size less than dipole antenna.
- Loop Antenna: They are cheap and not easily de-tuned by hand movements.
- Spiral Antenna: The size is less than whip antenna. It can be used for wideband applications.
- Helical Antenna: It is very directive antenna and provides good amount of gain.
- Microstrip Antenna: They are very simple and chip antenna. They are used in smartphone due to their thin structure.
- Ceramic Antenna: They are very small in size and are less affected due to environment factors. They are separate components.
- Slot Antenna: They are simple in design and are smaller in size. They are robust in nature.

1.5 Disadvantages of Antenna Types [4]

Following are the disadvantages of Antenna Types:

- Dipole Antenna: They exhibit large size at lower frequency.
- Whip Antenna: The higher cost is the major disadvantage. Better ground plane is needed to achieve good performance.
- Loop Antenna: They have poor gain, difficult to tune and are very narrowband.
- Spiral Antenna: The major disadvantage of this type of antenna is difficulty in feeding it.
- Helical Antenna: They are bulky in size. They are de-tuned by nearby objects very easily.

- Microstrip Antenna: They are large in size at lower frequency. PCB design affects performance and tuning. It is difficult to design for less than 433 MHz.
- Ceramic Antenna: They are higher in cost. They deliver medium performance. They are matching function of PCB size and ground plane shape.
- Slot Antenna: They are larger in size at lower frequency and hence it is difficult to design them for frequencies less than 433 MHz. [4]

1.6 Digital Fabrication

There is a research trend of producing the RF energy harvesting devices using new fabrication methods. The main driver of this trend is the reduction of cost, device customization and integration into the devices casing. The variations in the material and fabrication techniques can also enable the makers to have some variations in the output which often results in improvement of the desired results. The fabrication techniques [5] such as inkjet printing, 3D printing [6] can help the antenna designs have novel attributes because of the possible variations and uniformity in the conductivity and permittivity of the materials used, and also the possibility of producing 3 dimensional models.

1.7 Thesis outline

The salient features of Patch antenna and dipole antenna are introduced in Chapter 2.

Chapter 3 provides the design procedures for the geometric shape of patch and dipole antenna.

Chapter 4 displays the various findings derived from the simulated results.

In Chapter 5, the findings are compared and summarized.

Chapter 2

Microstrip patch antenna and Dipole Antenna

2.1 Microstrip patch antenna

Microstrip antennas are frequently used in today's wireless communication systems because of their low profile, light weight and low production cost which widely have been researched and developed in the recent twenty years. There are several disadvantages of microstrip Antenna. Narrow operation bandwidth is the main disadvantage. The bandwidth of the basic patch antenna is usually 1 -3%. The bandwidth of the antenna depends on the patch shape, dielectric constant, the thickness of the substrate and the resonant frequency. The design of microstrip antennas suitable for new WLAN to achieve dual-frequency or multi-band is developed in recent years. [7]

Microstrip or patch antennas are becoming increasing useful because they can be printed directly onto a circuit board. Microstrip antennas are becoming very widespread within the mobile phone market. Microstip antennas are becoming very widespread within the mobile phone market. Patch antennas are low cost, have a low profile and are easily fabricated. [8]

In its most basic form, a Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure. The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. Arrays of antennas can be photo etched on the substrate, along with their feeding networks. Microstrip circuits make a wide variety of antennas possible through the use of the simple photo etching techniques. [9]

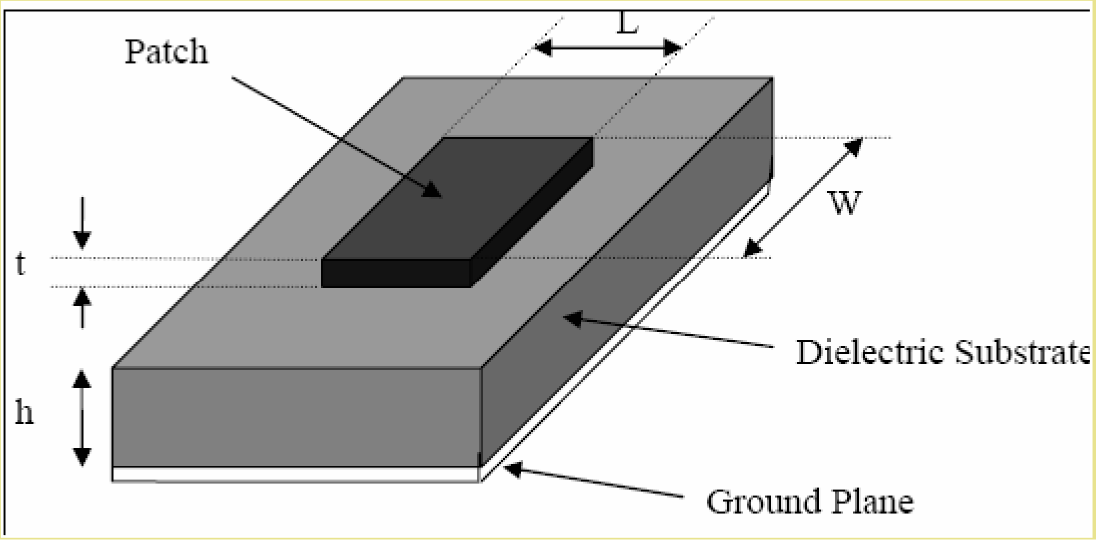

Fig 2.1: Typical Microstrip Patch Antenna

The half-Wave dipole antenna is just a special case of the dipole antenna, but its important enough that it will have its own section. Half-wave term means that the length of this dipole antenna is equal to a half-wavelength at the frequency of operation. [10]

2.1.1ADVANTAGES [8]

- low fabrication cost,hence can be manufactured in large quantities
- Easily integrated with microwave integrated circuits(MICs)
- Capable of dual and triple frequency operations
- Supports both linear as well as circuler polarization
- Low cost,less size, low mass
- Mechanically robust when mounted on rigid surfaces
- High performance
- Light weight and low volume

2.1.2 DISADVANTAGES [8]

- Narrow bandwidth associated with tolerence prolem
- Lower gain(nearly 6db)
- Excitation of surface waves
- Most microstrip antennas radiate into half space
- Relatively high level of cross polarization radiation
- Inherently low impedence bandwidth
- low efficiency

- Low power handling capacity

2.1.3Applications [11]

The microstrip patch antennas are famous for their performance and robust design. Microstrip patch antennas have applications in various fields such as in the medical field, satellites and even in the military systems just like in the rockets, aircrafts missiles and many more. Now they are booming in the commercial aspects due to their low cost of the substrate material and the fabrication. Microstrip patch antenna has a number of applications. Some of these applications are discussed as

- Mobile and satellite communication application
- Global positioning system applications
- Radio frequency identification (RFID
- Reduced size microstrip patch antenna for Bluetooth applications
- Interoperability for microwave access (WiMax)
- Broadband microstrip S-shaped patch antenna for wireless communication
- Radar application

2.2 Half wave dipole [12]

The half wave dipole is formed from a conducting element which is wire or metal tube which is an electrical half wavelength long. It is typically fed in the centre where the impedance falls to its lowest. In this way, the antenna consists of the feeder connected to two quarter wavelength elements in line with each other.

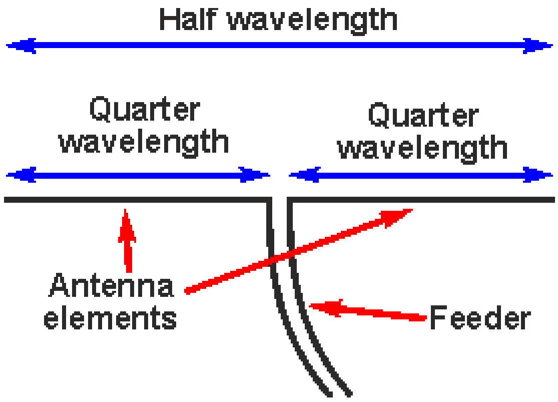

Figure2.2:Half wave dipole antenna[12]

The voltage and current levels vary along the length of the radiating section of the antenna. This occurs because standing waves are set up along the length of the radiating element.

As the ends are open circuit current at these points is zero, but the voltage is at its maximum. As the point at which these quantities is measured moves away from the ends, it is found that they vary sinusoidally: the voltage falling, but the current rising. The current then reaches a maximum and the voltage a minimum at a length equal to an electrical quarter wavelength from the ends. As it is a half wave dipole, this point occurs in the centre.

As the centre point is where the current is a maximum and the voltage is a minimum, this makes a convenient point to feed the antenna as it present a low impedance. This is much easier to feed as high RF voltages can present many problems for feeders and matching units.

For a dipole antenna that is an electrical half wavelength long, the inductive and capacitive reactances cancel each other and the antenna becomes resonant. With the inductive and capacitive reactance levels cancelling each other out, the load become purely resistive and this makes feeding the half wave dipole antenna far easier. Coaxial feeder can easily be used as standing waves are not present, and it is also much easier to match to a transmitter output that may only want to see a resistive load. Loads that include reactances lead to higher voltage of current levels that the transmitter may not be able to tolerate. The impedance for a half wave dipole antenna in free space is dipole 73 Ω which presents a good match to 70Ω coaxial feeder and this is one of the reasons why coax with this impedance was chosen for many applications.

2.2.1 Half wave dipole field strength [12]

It is possible to plot the field strength for an antenna at a distance from the radiating element to see its radiation pattern. For a complete 3D view of the radiation pattern both φ and θ angels are required. However to simplify the overall maths behind any calculations it is possible to express the field strength levels in the planes of interest. These are generally viewed as cross sections through the overall 3D pattern. The most frequently used one are the horizontal where φ=90° and the vertical planes.

$$E = \frac{60l}{r}\left(\frac{\cos\left(\frac{\pi}{2}\cos\theta\right)}{\sin\theta}\right) \dots\dots\dots\dots\dots.(1)$$

Using the half wave dipole formula given above it is possible to determine the radiation pattern of the half wave dipole antenna from the far field E vector.[4]

2.2.2 Half wave dipole radiation pattern & directivity [12]

Using the half wave dipole formula, it is possible to calculate the radiation pattern and hence determine the directivity. As expected the maximum half wave dipole directivity shows the maximum radiation at right angles to the main radiator.

At other angles, the angle θ in the half wave dipole formula above can be used to determine the field strength.

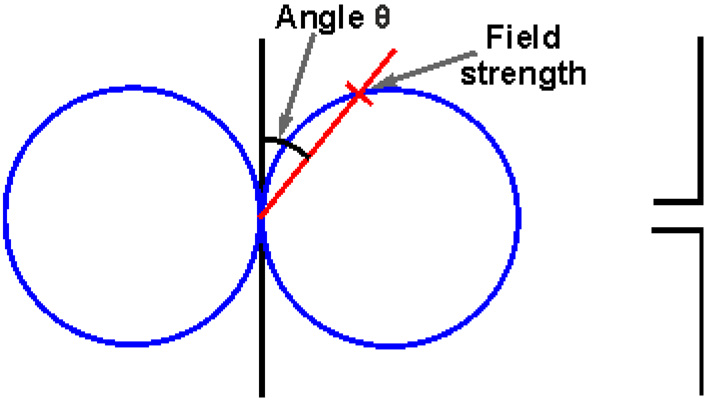

Figure 2.3: Half-wave dipole radiation pattern[12]

It is also possible to view the radiation pattern in terms of the plane looking around the dipole antenna, i.e. in the plane cutting the dipole in its field of maximum radiation.

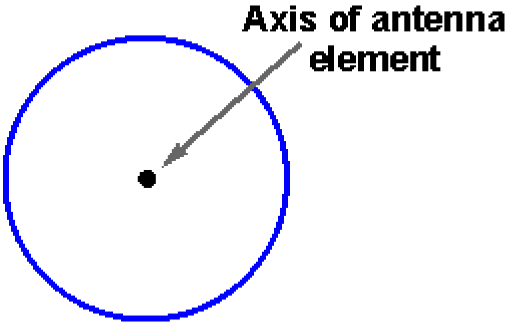

Figure 2.4:Pattern of radiation with axis of antenna in / out of screen[12]

As can be seen, with the axis of the antenna in / out of the screen, the level of radiation is the same all around the antenna. This is to be expected as there is nothing to distinguish one direction from another or to affect the radiation in different directions in this plane [4].

2.3 FEED/EXCITATION METHODS [1]

2.3.1TECHNIQUE:

A microstrip patch radiator can be fed or excited to radiate by many techniques; several common ones are listed and briefly discussed next.

2.3.2 Coax Probe Feed:

A microstrip patches can be fed by a 50-ohm coax probe from behind the ground plane, where the flange of the coax probe (outer conductor) is soldered to the ground plane. The center conductor pin penetrates through the substrate and the patch and is then soldered to the top of the patch. The location of the probe should be at a 50-ohm point of the patch to achieve impedance matching. There are various types of coax probes for different frequency ranges. Type N, TNC, or BNC can be used for VHF, UHF, or low microwave frequencies. OSM or OSSM can be used throughout microwave frequencies. OSSM, OS-50, or K-connector should be used for the millimeter-wave frequency range.

2.3.3 Coaxial Probe with Capacitive Feed:

For wider bandwidth (5–15%) applications, thicker substrate is generally used. If a regular coax probe were used, a larger inductance would be introduced, which results in impedance mismatch. In other words, the electrical field confined in the small cylindrical space of the coax cannot suddenly transition into the large spacing of the patch. To cancel the inductance occurring at the feed, capacitive reactance must be introduced. One method is to use a capacitive disk, where the patch is not physically connected to the probe. Another method is to use a "tear-drop" shaped or a cylindrical shaped probe as illustrated in figure. With this method the probe is soldered to the patch, where mechanical rigidity may be offered for some applications.

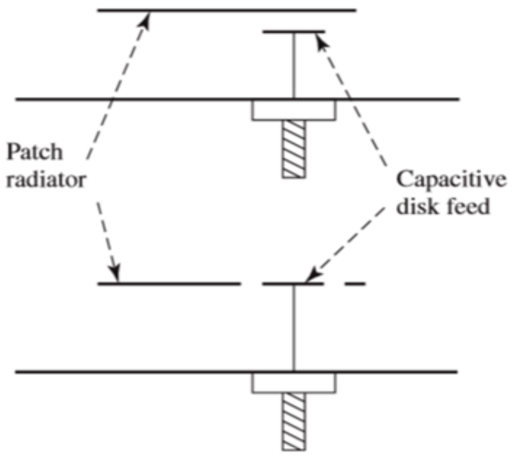	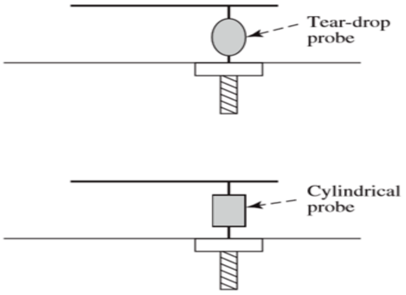
Figure 2.5: Two different capacitive feed methods for relatively thick substrates[2]	Figure 2.6:Tear drop and cylindrical shaped feed probes for relatively thick substrates[2]

Chapter 3

Structural Design

Introduction

3.1 CST STUDIO INTRODUCTION [13]

CST is a market leader in providing 3D electromagnetic (EM) field simulation tools through a global network of sales and support staff and representatives. CST develops CST STUDIO SUITE, a package of high-performance software for the simulation of EM fields in all frequency bands. Its growing success is based on a combination of leading edge technology, a user-friendly interface and knowledgeable support staff. CST solutions are used by market leaders in a diverse range of industries, including aerospace, automotive, defense, electronics, healthcare and telecommunications. CST is part of SIMULIA, a Dassault Systems brand.

Release Version 2016.00 - Jan 22 2016

- Portions of this software are owned by Spatial Corp.
  © 1986-2015. All rights reserved.
- The Qt GUI Toolkit is Copyright © 1994-2015
  The Qt Company Ltd.

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Figure 3.1: CST studio starting layout

3.2 SOLVING TECHNIQUES [13]

1. **High frequency:**
   - Transient solver – general purpose
   - Frequency domain solver – general purpose
   - Integral equation solver – electrically large structures, RCS
   - Asymptotic solver – installed performance, RCS
   - Eigen mode solver – resonant cavities
   - Multilayer solver – planar structures

- Filter Designer 2D – RF filter analysis and synthesis
- Filter Designer 3D – cross-coupled cavity filter synthesis

2. **Low frequency:**
   - Electrostatic / Magneto static – fast static simulation
   - Stationary current solver – DC applications
   - Time domain solver – non-linear materials, transient effects
   - Frequency domain solver – eddy currents, displacement current

3. **EDA:**
   - PEEC solver – boards without reference planes
   - Transmission line solver – signal integrity
   - 3D FEFD solver – power integrity
   - Rule Check – EMC and SI on PCB

4. **Particle dynamics:**
   - Particle tracking solver – low energy particles, electron guns
   - PIC solver – high energy particles, RF devices
   - Wake field solver – accelerator components

5. **Multiphysics:**
   - Thermal solvers – electromagnetic heating, bio heat
   - Structural mechanics solver – thermal expansion, deformation

6. **EMC:**
   - Transmission line matrix (TLM) solver – general purpose, EMC
   - Cable solver – cable harness simulation
   - Rule Check – EMC and SI on PCBs.

3.3Microstrip Antenna Design Parameteres [8]

All of the parameters in a rectangular patch antenna design (L, W, h, permittivity) control the properties of the antenna. As such, this page gives a general idea of how the parameters affect performance, in order to understand the design process. First, the length of the patch L controls the resonant frequency as seen here. This is true in general, even for more complicated microstrip antennas that weave around - the length of the longest path on the microstrip controls the lowest frequency of operation. Equation (1) below gives the relationship between the resonant frequency and the patch length:

$$f_c \approx \frac{c}{2L\sqrt{\varepsilon_r}} = \frac{1}{2L\sqrt{\varepsilon_0 \varepsilon_r \mu_0}}$$ ………………(1)

Second, the width W controls the input impedance and the radiation pattern (see the radiation equations here). The wider the patch becomes the lower the input impedance is. The permittivity epsilon r permittivity (dielectric constant) of the substrate controls the fringing fields - lower permittivities have widerfringes and therefore better radiation. Decreasing the permittivity also increases the antenna's bandwidth. The efficiency is also increased with a lower value for the permittivity. The impedance of the antenna increases with higher permittivities.

Higher values of permittivity allow a "shrinking" of the patch antenna. Particularly in cell phones, the designers are given very little space and want the antenna to be a half-wavelength long. One technique is to use a substrate with a very high permittivity. Equation (1) above can be solved for L to illustrate this:

$$L \approx \frac{1}{2f_c\sqrt{\varepsilon_0 \varepsilon_r \mu_0}}$$ …………………………..(2)

Hence, if the permittivity is increased by a factor of 4, the length required decreases by a factor of 2. Using higher values for permittivity is frequently exploited in antenna miniaturization.

The height of the substrate h also controls the bandwidth - increasing the height increases the bandwidth. The fact that increasing the height of a patch antenna increases its bandwidth can be understood by recalling the general rule that "an antenna occupying more space in a spherical volume will have a wider bandwidth". This is the same principle that applies when noting that increasing the thickness of a dipole antenna increases its bandwidth. Increasing the height also increases the efficiency of the antenna. Increasing the height does induce surface waves that travel within the substrate (which is undesired radiation and may couple to other components).The following equation roughly describes how the bandwidth scales with these parameters:

$$B \propto \frac{\varepsilon_r - 1}{\varepsilon_r^2} \frac{W}{L} h$$ ……………………..(3)

3.3.1 THE TRANSMISSION LINE EQUATIONS :[14]

1) To find Width (W) :

$$W = \frac{c}{2 f_{\circ} \sqrt{\frac{(\varepsilon r+1)}{2}}}$$

....(4)

2)TO FIND THE EFFECTIVE DIELECTRIC CONSTANT:

$$\varepsilon_{reff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left(1+12\,\frac{h}{W}\right)^{-1/2}$$

.... (5)

3) TO FIND THE EFFECTIVE LENGTH:

$$L_{eff} = \frac{c}{2 f_{\circ} \sqrt{\varepsilon reff}}$$

.....................................(6)

4) TO FIND THE FRINGING LENGTH (ΔL) :

$$\Delta L = 0.412\, h\, \frac{(\varepsilon reff+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon reff-0.258)\left(\frac{W}{h}-0.8\right)}$$

…………………………….(7)

5) To find the actual length L and the width and length of the Ground:

……………………………………………………….(8)

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

Lg=2∗L , Wg=2*W

6) The length of inset (Fi) :

Fi= 10^4*.001699∗εr7+0.13761∗εr6−6.1783∗εr5+93.187∗εr4−682.69 ∗εr3..... (9)

7) The feed line width of (Wf) :

$$w = \frac{7.48 \times h}{e^{\left(Z_0 \frac{\sqrt{\varepsilon_r+1.41}}{87}\right)}} - 1.25 \times t$$

`......................................(10)

3.3.2 PARAMETERS

We took different inset feed value for the square microstrip antenna. And we have got 3 different s-parameters. We mainly used FR-lossy material for the antenna. The box shown below is all the parameters we used for the design of the microstrip antenna.

Parameter Name	**FR-lossy** **ε_r (4.3)**
Width (w)	35.359
Length (l)	65.359
feed line width (wf)	5
gap-patch an feed (Gpf)	1
Ground length (lF)	46.20
Ground width(wf)	5
Height-conductor(Mt)	0.1
Substrate (h)	5.5

3.3.3 PART DESIGNING OF AN ANTENNA

This are the process we have gone through while designing the desire antenna

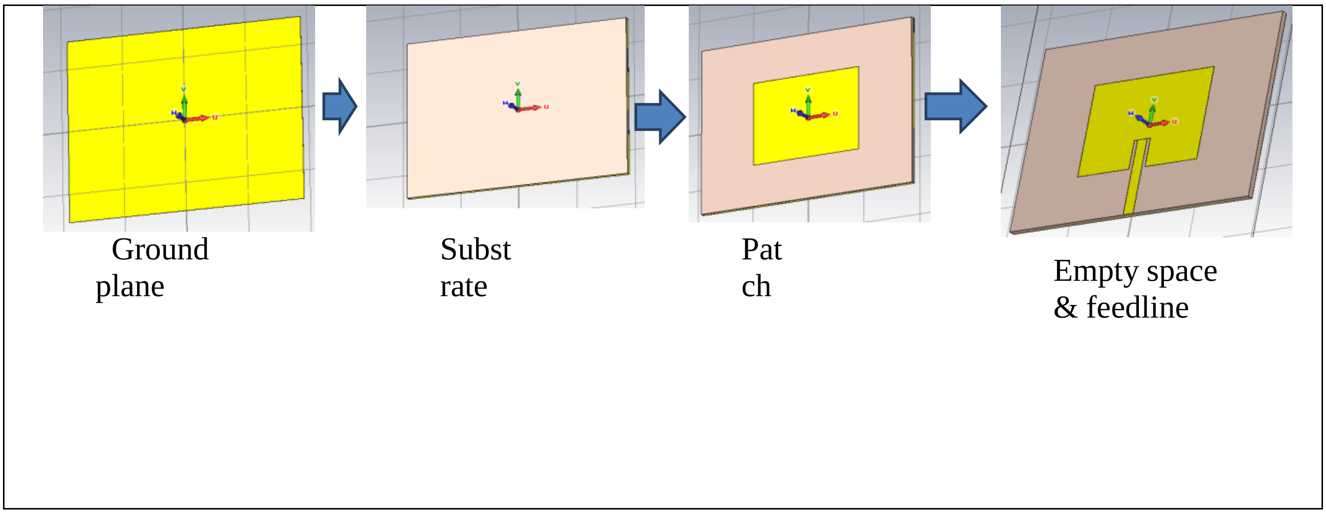


Figure 3.2(a): Different parts of an antenna

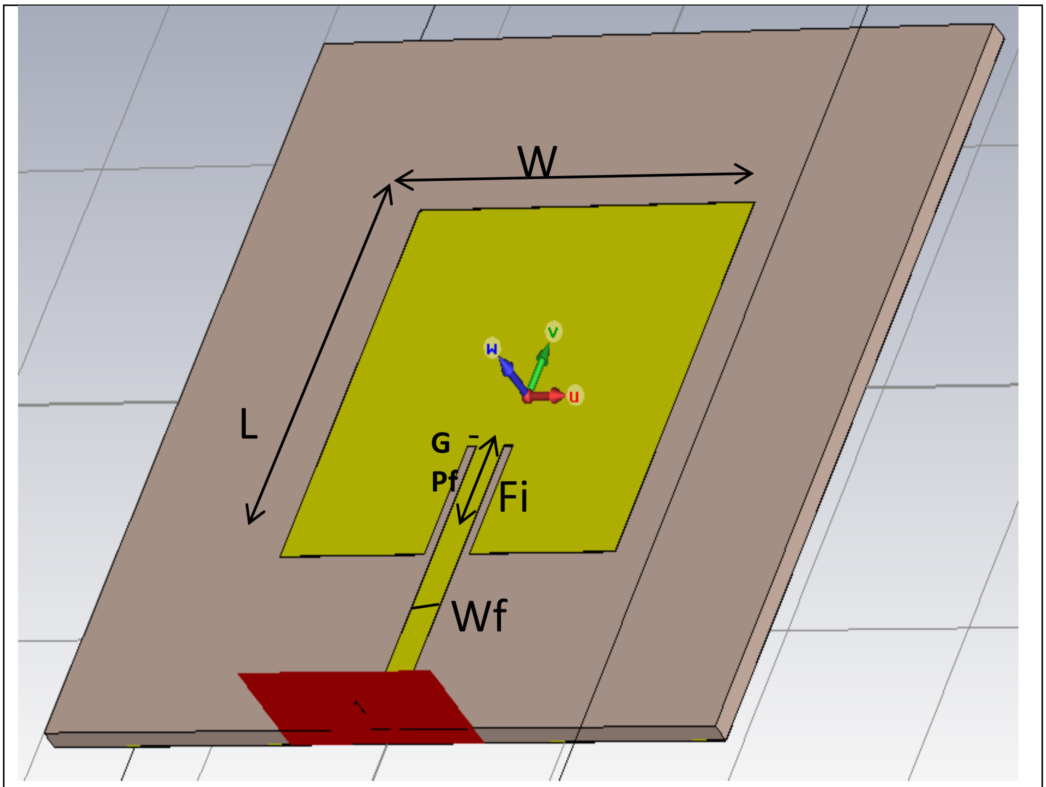


Figure 3.2(b):Complete patch antenna

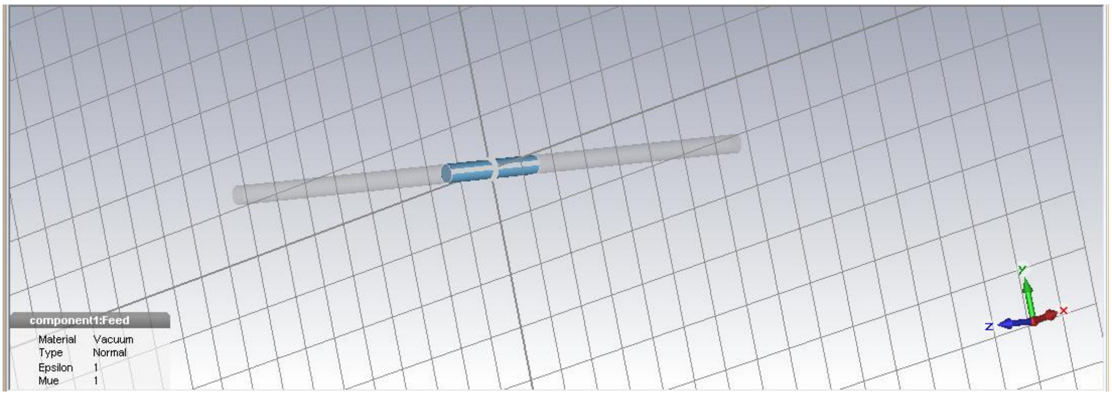
So in Figure 3.3(b) this the complete patch antenna with labeling in 3D view where Gpf means (gap between patch and inset feed) and Wf (width of the feed line) and Fi means (length of the inset feed).

3.4 Dipole Antenna Design Parameteres

A dipole antenna was designed to match at the 2.43 GHz band using CST. The dimensions of the antenna are given in the table 3.4.

Table 3.1: Parameter list

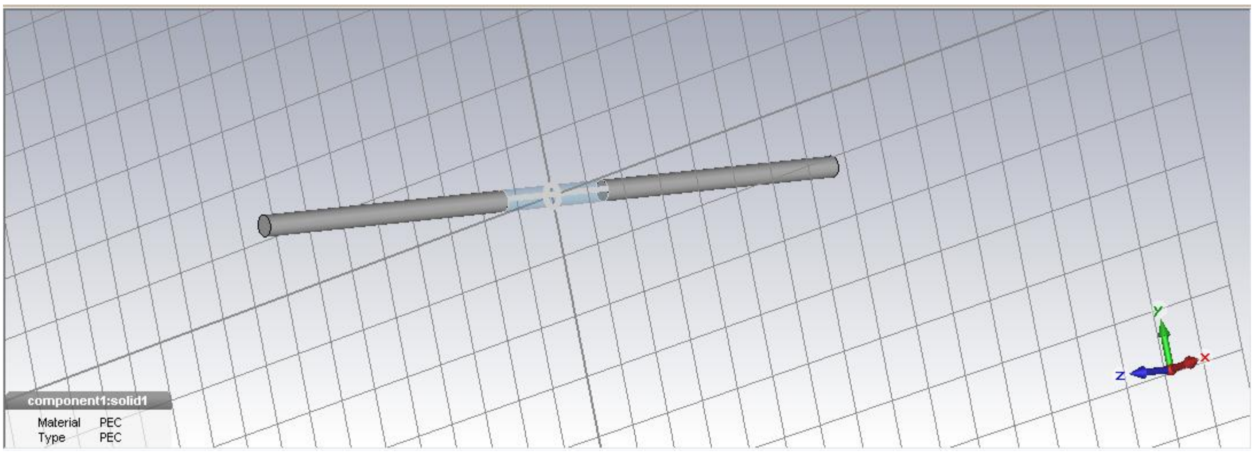
Parameter list	Value	Description
a	.876	Multiplication factor
F	10	Length of the feed
L	65*a	Length of the dipole
R	0.9	Radius of the dipole
Z	85	Input Impedance



component1:Feed

Material Vacuum
Type Normal
Epsilon 1
Mue 1

Fig 3.3(a): Feed layout of the antenna



component1:solid1

Material PEC
Type PEC

Fig 3.3 (b): Solid layout of the antenna

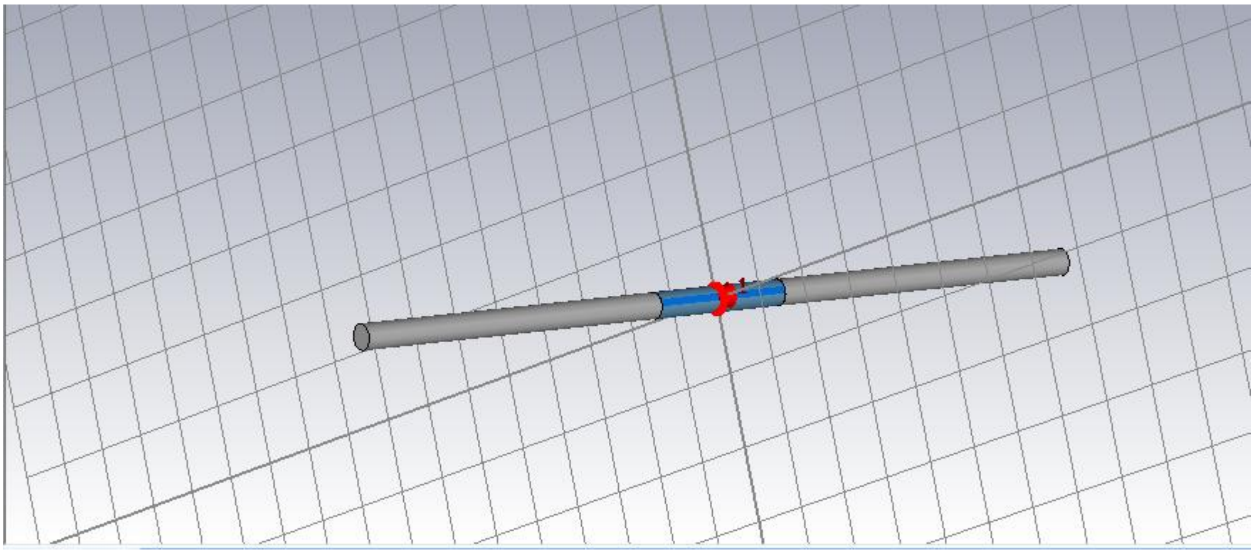


Fig 3.3 (c): Complete layout of the antenna

Chapter 4

Simulated Result

4.1 Simulation Results

After successfully design the antenna in CST studio suite, Now it's time for the simulation part where we can check the bandwidth through "S-parameter", can also check the Gain, Realized Gain , Far-field, H-field, Balance, Efficiency, VSWR (voltage Standing Wave Ratio). So we were simulated our antenna through Time Domain Solver Parameter, in figure 4.1 successfully simulated message is displayed for our antenna

4.2 S11 PARAMETERS: OUR PROPOSED ANTENNA (Patch Antenna)

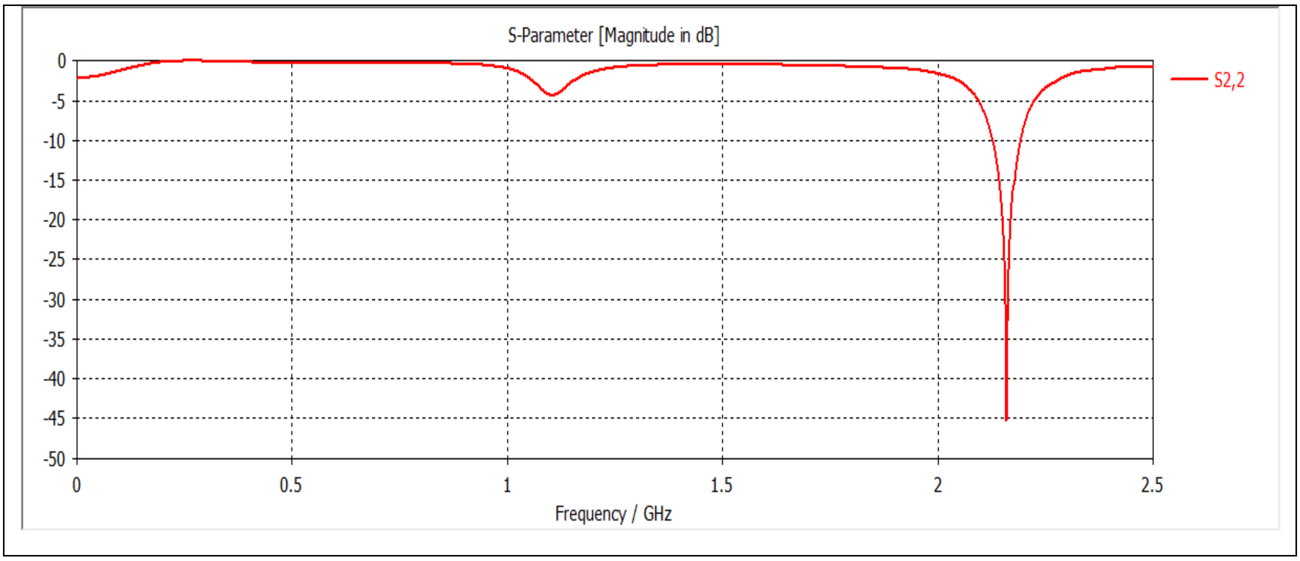


Figure 4.1: S11-Parameter of microstrip patch antenna at 2.16 GHz

4.3 Parametric Analysis of S11-Parameters

The parametric analysis has been done for finding better S11-Parameters at different frequencies from 2.1 GHz to 2.4 GHz and also from 2.5 GHz to 5GHz.

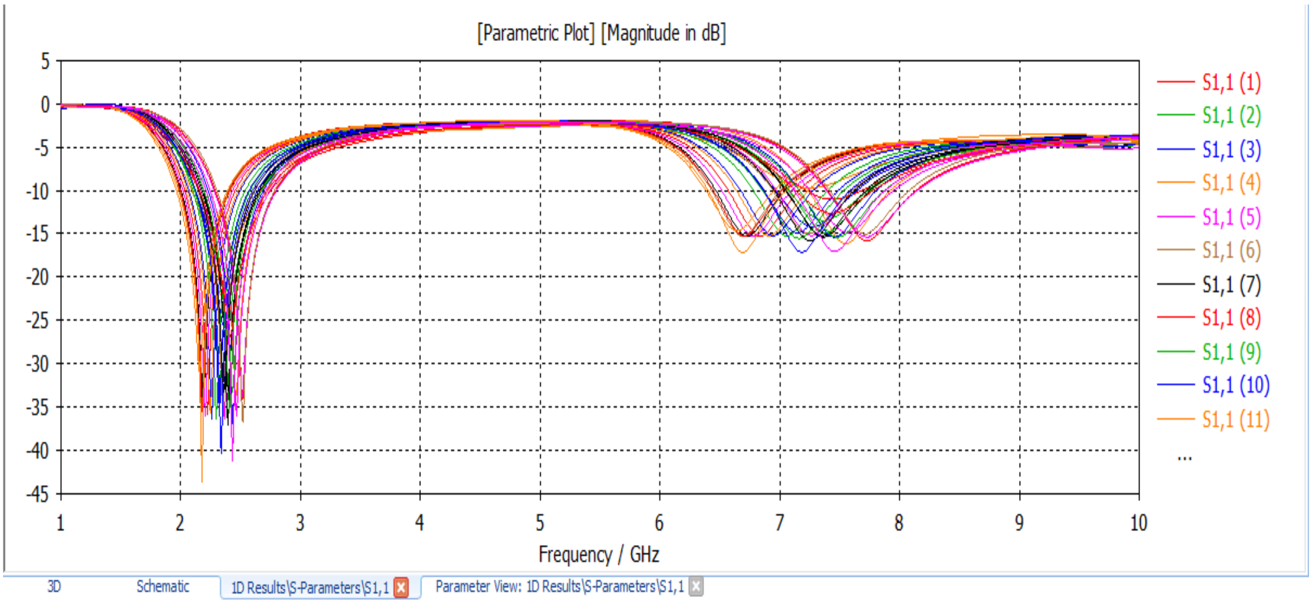
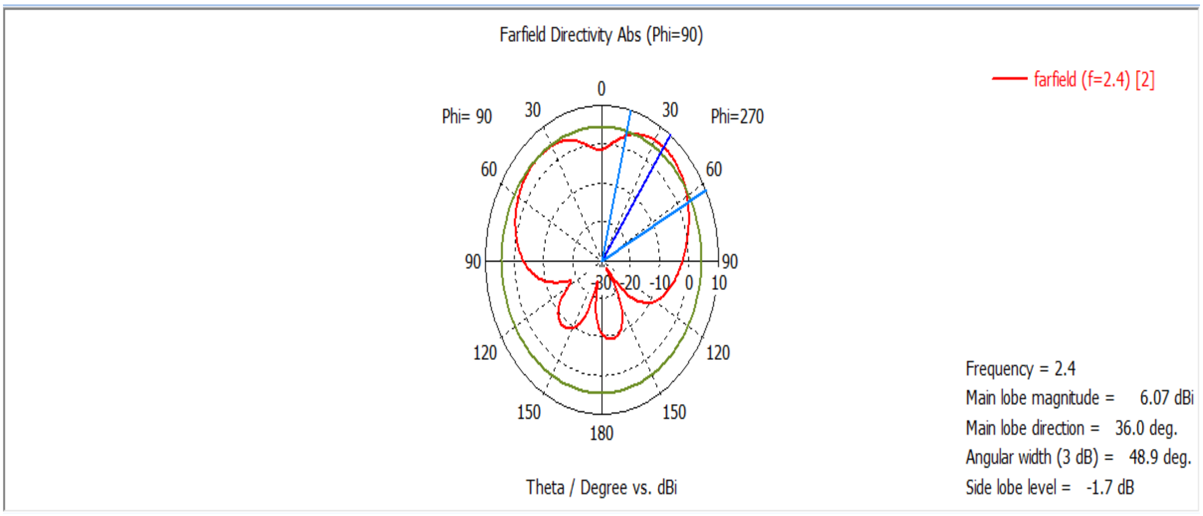


Figure 4.2: Parametric Analysis

4.4 RADIATION PATTERN

The far field is the region far from the antenna, as you might suspect. In this region, the radiation pattern does not change shape with distance (although the fields still die off as 1/R, the power density dies off as 1/R^2). Also, this region is dominated by radiated fields, with the E- and H-fields orthogonal to each other and the direction of propagation as with plane waves.



Frequency = 2.4
Main lobe magnitude = 6.07 dBi
Main lobe direction = 36.0 deg.
Angular width (3 dB) = 48.9 deg.
Side lobe level = -1.7 dB

Figure 4.3(a): Far Field Radiation pattern in polar form

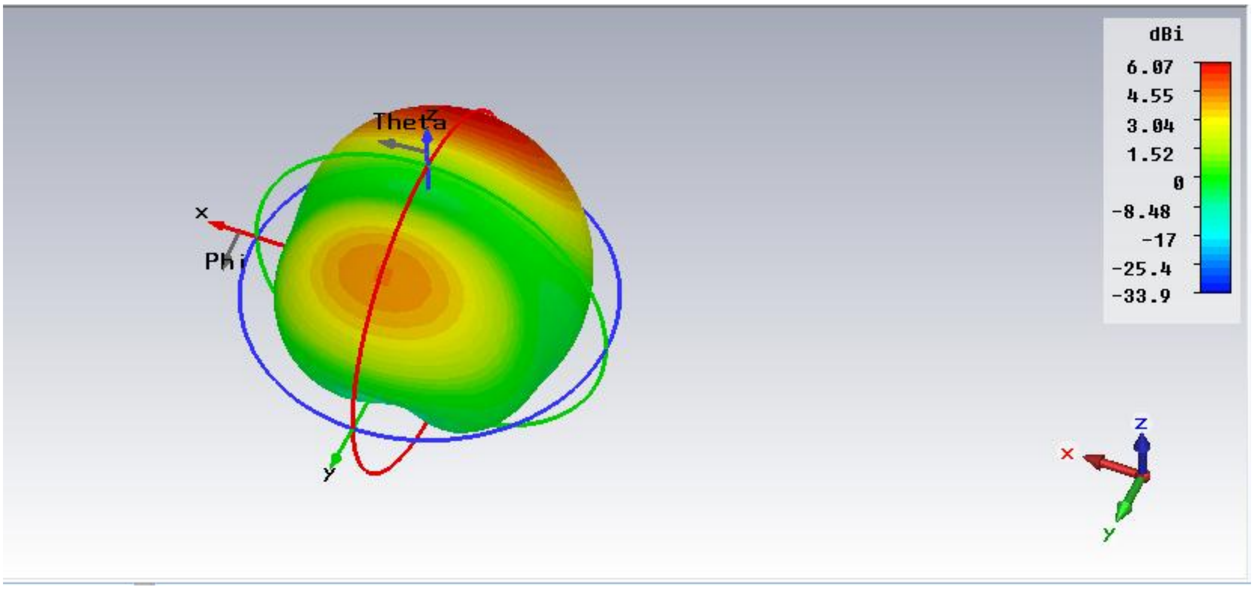


Figure 4.3(b): 3D far field plot

4.5 S PARAMETERS: OUR PROPOSED ANTENNA (Dipole Antenna)

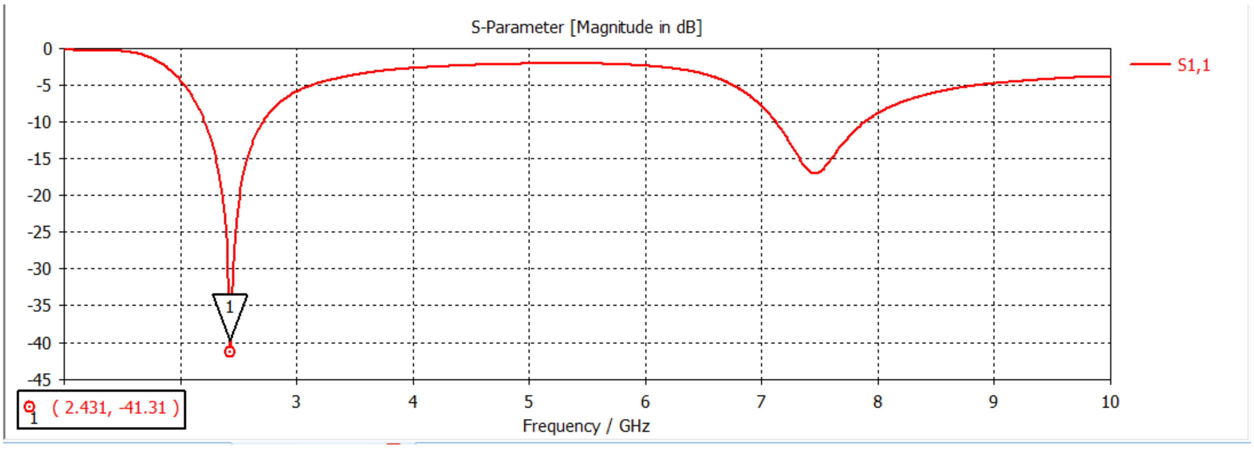
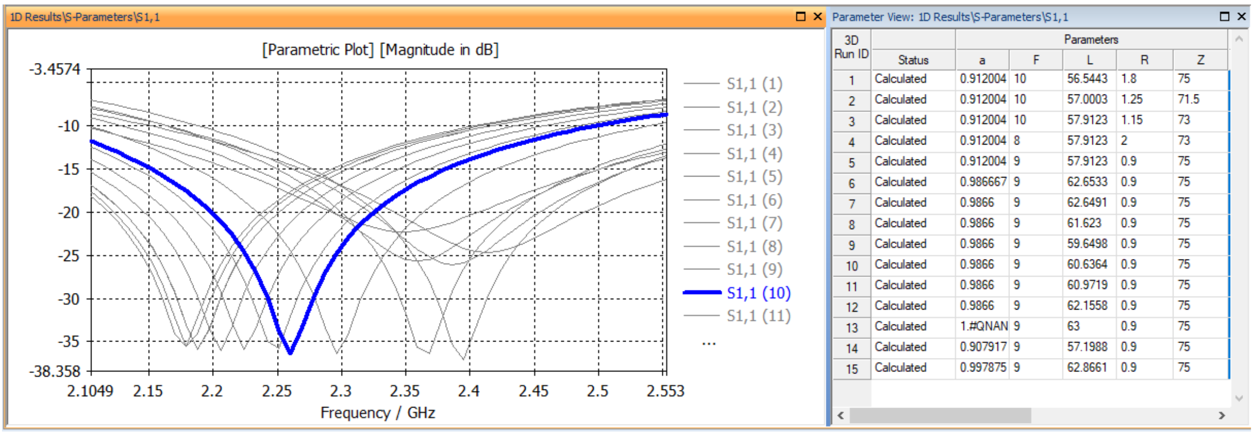


Figure 4.4:S11-Parameter of dipole antenna

4.6 Parametric Analysis of S-Parameters

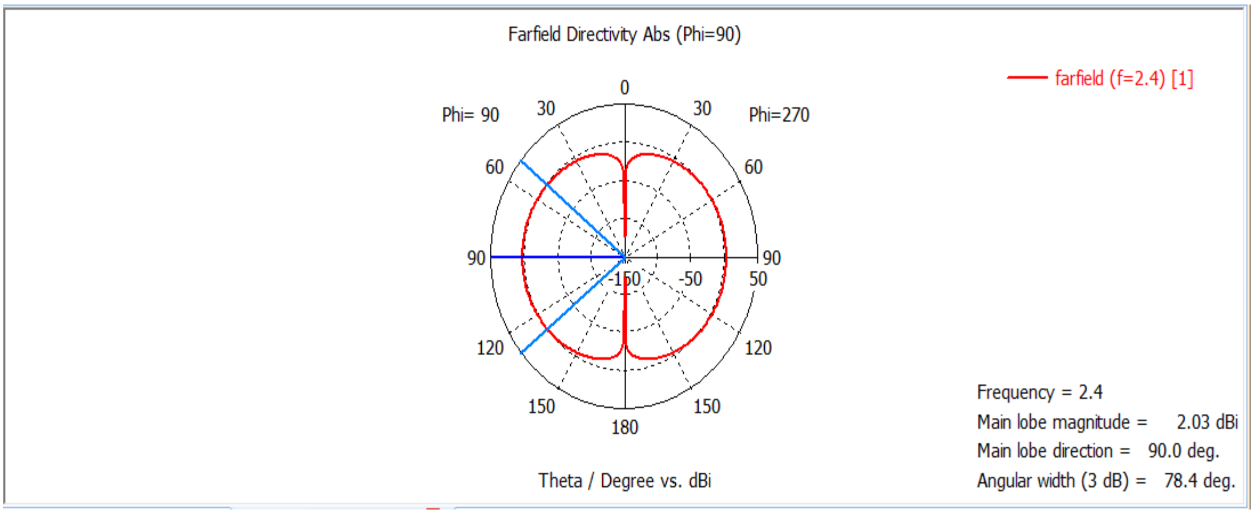


Parameter View: 1D Results\S-Parameters\S1,1

3D Run ID	Status	Parameters				
		a	F	L	R	Z
1	Calculated	0.912004	10	56.5443	1.8	75
2	Calculated	0.912004	10	57.0003	1.25	71.5
3	Calculated	0.912004	10	57.9123	1.15	73
4	Calculated	0.912004	8	57.9123	2	73
5	Calculated	0.912004	9	57.9123	0.9	75
6	Calculated	0.986667	9	62.6533	0.9	75
7	Calculated	0.9866	9	62.6491	0.9	75
8	Calculated	0.9866	9	61.623	0.9	75
9	Calculated	0.9866	9	59.6498	0.9	75
10	Calculated	0.9866	9	60.6364	0.9	75
11	Calculated	0.9866	9	60.9719	0.9	75
12	Calculated	0.9866	9	62.1558	0.9	75
13	Calculated	1.#QNAN	9	63	0.9	75
14	Calculated	0.907917	9	57.1988	0.9	75
15	Calculated	0.997875	9	62.8661	0.9	75

Figure 4.5: S-parameters for different dimensional values

4.7 RADIATION PATTERN (Dipole Antenna)



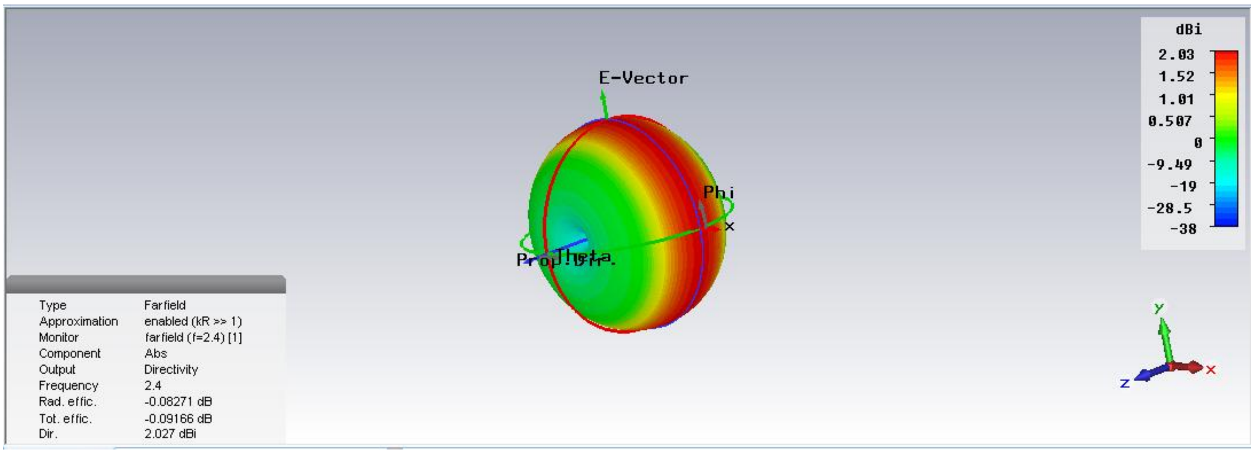
Frequency = 2.4

Main lobe magnitude = 2.03 dBi

Main lobe direction = 90.0 deg.

Angular width (3 dB) = 78.4 deg.

Figure 4.6(a): Far Field Radiation pattern in polar form



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=2.4) [1]
Component	Abs
Output	Directivity
Frequency	2.4
Rad. effic.	-0.08271 dB
Tot. effic.	-0.09166 dB
Dir.	2.027 dBi

Figure 4.6(b): Far Field Radiation pattern in 3D (abs component)

Chapter 5

Conclusion & Discussion

5.1 Conclusion

Our work was compared with some recent works.

Table 5.1:Return Loss Comparison table

Antenna	**Frequency**	**Return loss(our work)**	**Return loss(Recent work)**
Dipole	**2.43GHz**	**-41.31dB**	**-21dB[15]**
Microstrip Patch	**2.16GHz**	**-45dB**	**-30dB[16]**

5.2 Discussion

In this paper we have discussed a rectangular microstrip antenna & Dipole Antenna which is around 2.16 GHz & 2.43GHz respectively. We have operate it at frequency band 2GHz to 2.4 GHz. The return loss at 2.16GHz frequency is below -45dB & for Dipole antenna the return loss we found was -41.31dB. For a better result we have changed inset feeding many times to come up with best result. We search and studied several things until we get the best possible result for our desired antenna. And this paper will help to have a better mobile satellite communication in future.

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