DESIGN AND ANALYSIS OF A PLANAR MONOPOLE ANTENNA’S FOR UWB APPLICATIONS

A thesis submitted in partial fulfillment of the requirement for the degree of

M.Tech Dual Degree
In
Electrical Engineering

Specialization: Electronics Systems and Communication

BY

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DEPARTMENT OF ELECTRICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

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Under the guidance of

Prof. K.R. Subhashini

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CERTIFICATE

This is to certify that the thesis entitled "DESIGN AND ANALYSIS OF A PLANAR MONOPOLE ANTENNA FOR UWB APPLICATIONS" by PULICHERI SURESH, in partial fulfillment of the requirements for the award of the degree of M.Tech DUAL DEGREE in ELECTRICAL ENGINEERING with specialization in ELECTRONICS SYSTEMS AND COMMUNICATION during session 2010-2015 in the Department of Electrical Engineering, National Institute of Technology Rourkela, is a true work completed by him under our watch and direction. To the best of our insight, the matter encapsulated in the thesis has not been submitted to some other University/Institute for the grant of any Degree or Diploma

Date: Prof. K.R.Subhashini

Place-Rourkela Department of Electrical Engineering

National Institute of Technology, Rourkela.

Acknowledgement

With a deep sense of gratitude, I want to express my sincere appreciation and respect to my guide, Prof.K.R. Subhashini , for being the corner stone of my project. It was his relentless inspiration and direction amid times of questions and vulnerabilities that has helped me to go ahead with this undertaking. In this content I also thank Mr. ANUP KUMAR PANDA, Head of the Department, Electrical Engineering, NIT Rourkela. I likewise need to thank my parents. I want to impart this snippet of joy to my guardians and relative .They rendered me enormous support during the whole tenure of my stay in NIT Rourkela. Finally, I would like to thank all whose direct and indirect support helped me to completing my semester project report in time. I would like to thank our department for giving me the opportunity and platform to make my effort a successful one.

PULICHERI SURESH
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CONTENTS

ABSTRACT

The proposed antennas are intend to utilize between 3 to 12 GHz.It consists of a Microstip patch, substrate and a ground plane. The characteristics of the antenna are mentioned. Microstrip antennas have a narrow bandwidth, so bandwidth enhancement is sometimes demanded for sensible applications. Additionally, applications in contemporary communication systems typically need compact antenna size so as to satisfy the miniaturisation needs of mobile units. Thus, size reduction and bandwidth enhancement have become major prototype issues for sensible applications of microstrip antennas

. Microstrip or patch antennas are becoming to be more and more valuable on the grounds that they will be printed specifically onto a board. They're broadly speaking used as a vicinity of flying machines, satellites, mobile, wireless application wherever size, weight, cost, easy installation, mechanics profile area unit constraints, and low profile like Micro strip antennas is also required.

This thesis has the design of Microstrip antennas for wireless applications. Three antennas designed. The first design is a Dual band Microstrip antenna which produces dual band characteristics. The second design is a Wideband Microstrip antenna that has wideband characteristics and the third antenna is a Circular Disc Monopole Antenna for ultra wideband applications

CHAPTER 1

MICROSTRIP PATCH ANTENNA

1.1 Introduction

The microstrip patch antenna comprises of a transmitting fix, substrate and ground plane. The patch stays as the upper layer. The ground plane lies on the base. In the middle of emanating fix and ground plane there lies the substrate. The substrate is made of PEC material. The radiating patch and the feed lines are commonly photograph scratched on dielectric substrate

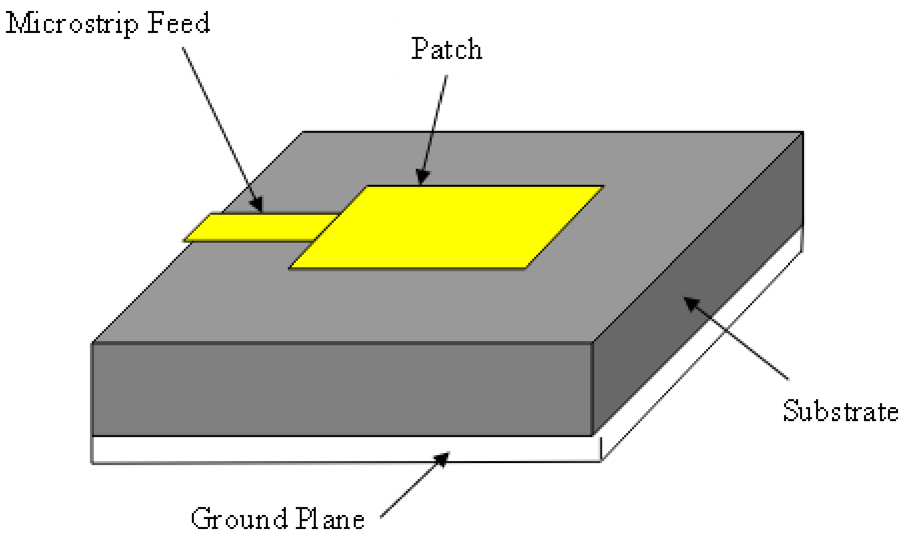

Fig 1.1 microstrip patch antenna Design

The radiating patch is generally is square, rectangular, circular, triangular and roundabout. If there should be an occurrence of rectangular patch, the length L of the patch is commonly lies between 0.3333λo to 0.5 λo, where λo is the free-space wavelength. It has by and large the thickness of t where t << λo. The thickness h of the substrate is for the most part $0.05\ \lambda o \geq h \geq 0.003\ \lambda o$ The scope of the dielectric steady of the substrate by and large lies in the middle of 2.2 to 12. For better radiation properties, a thick dielectric substrate is taken which is having a low dielectric steady is appealing since it gives better productivity. So, we can obtain higher transmission capacity. Henceforth, design must be analyzed for the antenna execution.

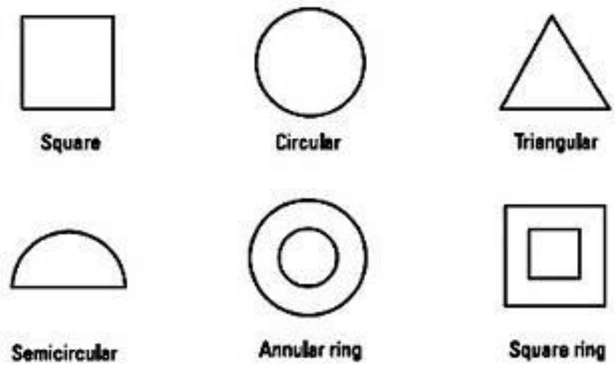

Fig 1.2: Distinct faces of microstrip patches

1.2 Advantages And Disadvantages

• They have low weight and volume.

• Manufacture cost is inexpensive.

• They can be printed with MMICs (Monolithic Microwave Integrated Circuits).

• They can designed in such a way that dual band, triband and wideband characteristics can be obtained.

• Both linear and circular polarization can be obtained.

• They have low profile planar setup.

Microstrip patch antennas also have more disadvantages:

• Power handling ability is low.

narrow bandwidth

•Inappropirate radiation from feeds, junctions.

• Efficiency is small.

• Gain is low

Excitation of surface waves

1.3. Design parameters

The resonance frequency for the (1, 0) mode according to Balanis[1] is

$$f_{\circ} = \frac{c}{2Le\sqrt{\epsilon_r}}$$

Where c = speed of light at the vacuum. The effective length Le is calculated as

L = Le - 2ΔL

2 $$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)}$$

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

1.4. Feed Techniques

The feeding techniques used for microstrip patch antennas are**:**

1.4.1: Microstrip Line Feeding

it is otherwise referred to as conducting strip, it's a lot of littler dimension once it's contrasted and therefore the patch. Its easy to manufacture simple |and straight forward to be get match for the dominant inset position and fairly mild to model. Because the substrate wideness expands surface waves and radiation in addition increments

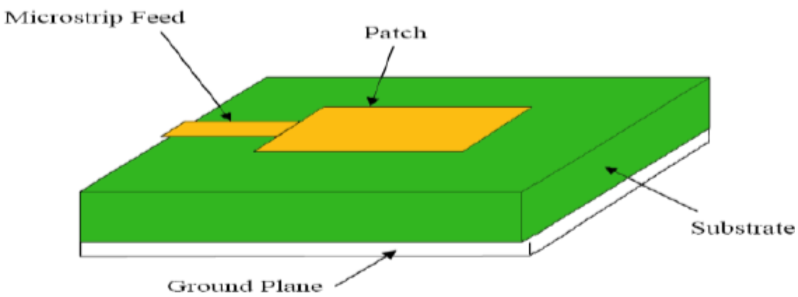

Fig 1.3: Microstrip Feed Line

1.4.2 C oaxial Feed

The coaxial feed is a basic procedure utilised for the sustaining the Microstrip antennas. The inner transmitter of the line conductor penetrates through the internal and is welded to transmission patch, whereas the external conduit is related to bottom plane

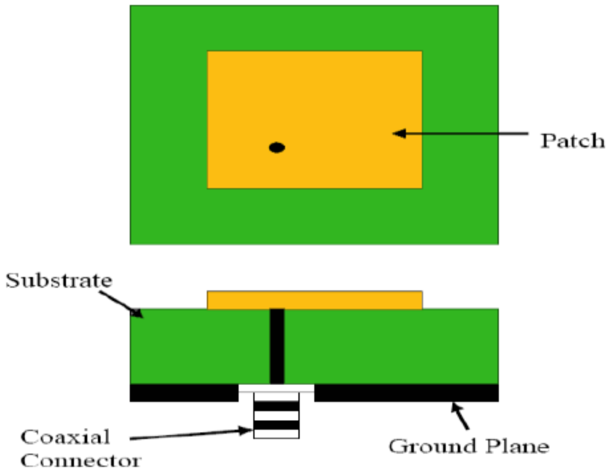

Fig 1.4: coaxial feeding technique

The feed is definitely not troublesome to develop and have low spurious radiation. In any case, a major injury is that it offers shock information trade confine and is tough to model taking when a gap should be depleted within the substrate and therefore the connection stretches out exterior of the ground plane, during this manner not creating it fully planar for wide substrates (h 0.02λo). Besides, for wider substrates, the amplified check length makes the knowledge impedance a lot of inductive, instigating orchestrating problems. The microstrip line sustain and therefore the coaxial feed encounter the evil impacts of various blocks. The non-coming to encourage procedures that are mentioned beneath, light up these problems

1.4.3 Aperture Coupled Feed

In aperture coupled feeding approach, the patch and feed line is separate by ground plane. The radiating patch is excited by an feed line through the slot in ground plane.

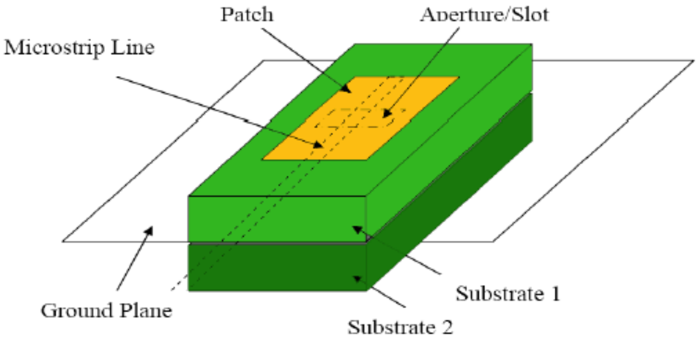

Fig 1.5 Aperture coupled feed

Aperature coupling includes of a two layer substrate inaccessible by ground plane, with the microstrip line on base layer whose vitality is coupled to fix through an area on the bottom plane isolating the two substrates as its identical circuit. the diverging radiating the bottom plane within the middle of the substrates is to induce the feed from the emanating part and reduces obstructions of spurious radiation for instance development and polarization spotlessness. Frequently for the base substrate a high dielectric material is employed, and across low dielectric consistent material for head substrate. For this set up, the substrate electrical parameters is utilised to outline the simplest one.

1.4.4 Proximity coupling

This kind of feeding system is likewise referred as the non-magnetic coupling feeding technique It basically uses two substrates and transmitting patch is on head of upper substrate. Feed line is situated under the upper substrate and the ground plane is put under the lower substrate. In this kind of system there is no spurious sustenance radiation and transmission cutoff is high. This sort of system is for the most part capacitive

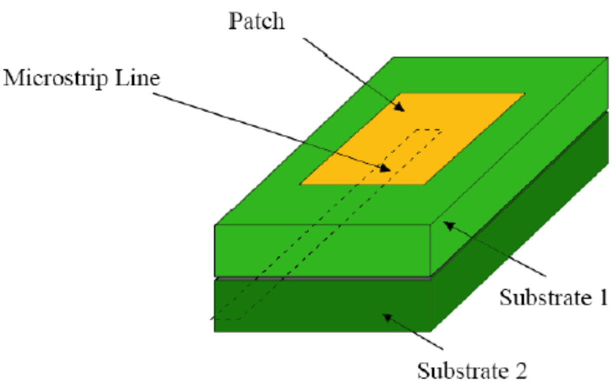

Fig1.6: Proximity Feed method

1.4.5 Coplanar waveguide Method

Coplanar wave guide is that favored Transmission line used for incase of MMICs .Both microstrip patch antennas and CPW are within the Planar type of the geometry. The MMICs for incorporating microstrip patch antennas, it's desirable over microstrip reception apparatuses with the CPW. By means that of a gap coupling is incised. The distinction between gap coupling and planar wave aide is that within the gap coupled microstrip radio wires,the space in the groundplane is sustain by a miocrostrip line

1.5 Method of study

There are a few techniques for the examining microstrip antennas are transmission line, depression and full wave model. The transmission model is less unpredictable and is fathomable however it is less exact. Though it is more intricate when contrasted with transmission model and it is more exact gives incredible physical information. The full wave model is correct and restricted and boundless bunches, subjectly formed segments and coupling. These models give less seeing when contrasted with past models

1.5.1 Transmission Line Model

The microstrip patch antenna's are represented by array of the two radiating apertures, each of width W and substrate height separated by length

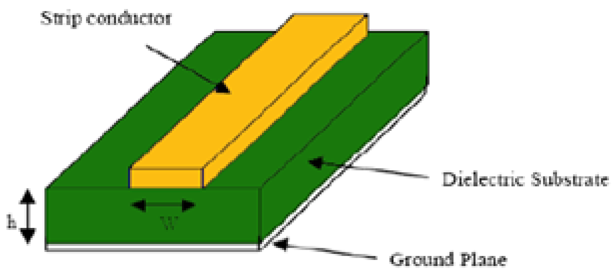

Fig 1.7: Microstrip feed line

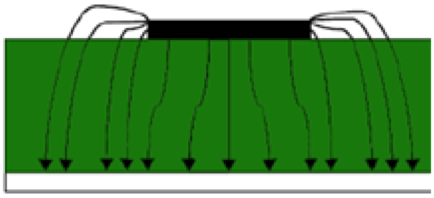

Fig 1.8: Electric field lines

. A large portion of electrical field lines invade within the substrate and the elements of 2 or 3 lines recognizable all around. During this manner, this transmission line cannot strengthen the stainless TEM framework for transmission since the speeds would be specific perceptible all throughout and also the substrate. Possibly, the stunning framework for the increase may be the semi TEM mode

The successful dielectric steady is an element of recurrence. The count of ϵ_reff is lower than the ϵ_r because of certainty that the bordering fields across the periphery are not to bound the substrate rather similarly noticeable

The ϵ_{reff} formula is

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}(1+\frac{12h}{W})^{\frac{-1}{2}}$$

Where

h = dielectric substrate height

ϵ_{reff}

ϵ_r = substrate dielectric constant

W = patch width

ϵ_{reff} = the dielectric constant

In the fig 1.8 the microstrip patch antenna

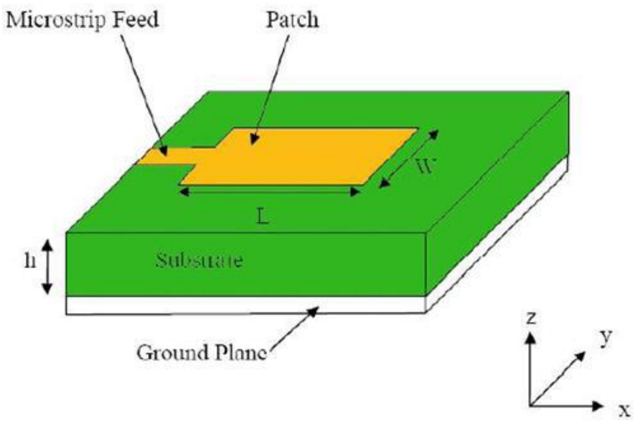

Fig 1.9: Microstrip antenna

For act within central TM10 patch length should be immaterial not unequivocally λ/2 wherever λ is that wavelength within nonconductor medium and actually indistinguishable to $\frac{\lambda_\circ}{\sqrt{\epsilon_{reff}}}$ where λo = free space wavelength. The TM10 mode proposes the field moves one λ/2 cycle on length, there is no mixed sack on the dimension of the patch. Within the Fig 1.10 showed beneath, the microstrip antenna had an inclination to by 2 areas. on the dimension of the patch, the voltage is most discriminating and current is scarcest by righteousness of the open culminations. The edge fields are often resolute into run of the mill and tangential divides with relevancy the bottom plane.

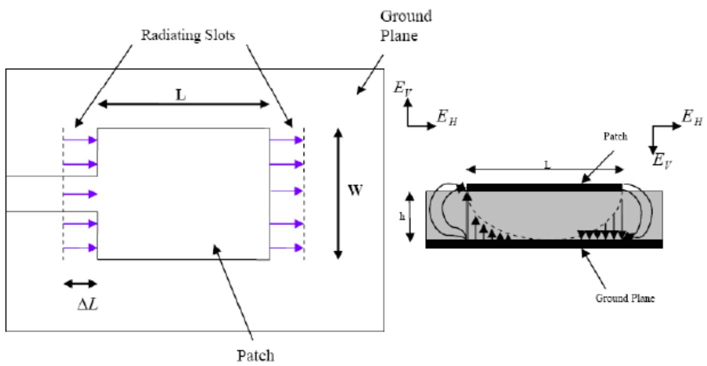

Fig1.10 Top and bottom view of microstrip antenna

the Fig 1.10 the quality components of electrical field at 2 edges on dimension ar backward course and out of the stage taking when the patch is λ/2 extended and consequently incise each with the other within the broadside postures with the tangential elements (found Fig 1.10, that ar in stage, induces that the resulting fields be part of to provide most chic shocking field regular to surface structure. Thusly,edges on width may associated with 2 transmission areas, that ar λ/2 possessed with stage and the transmission in the half-space at ground plane. In the Bordering fields at the width may be demonstrated as transmission openings the patch of microstrip nondirectional antenna equipment appearance a bigger variety of perceptible than its physical estimations. Estimations of patch and the length currently been joined on the each finish by the partition ΔL, it is given as in equation 1.3

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

Where

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

The Leff can be calculated as

Leff = L +2ΔL

For the effective length Leff the Resonance frequency fr would be

$$L_{eff} = \frac{c}{2f_r\sqrt{\epsilon_r}}$$

Resonance frequency for any TMmn , the rectangular microstrip antenna , the width W is given as

$$W = \frac{1}{2f_r\sqrt{\mu_\circ\epsilon_\circ}}\sqrt{\frac{2}{\epsilon_{reff}+1}} = \frac{c}{2f_r}\sqrt{\frac{2}{\epsilon_{reff}+1}}$$

1.5.2 The Cavity Model:

For this type quite model, the stretch between patch and ground plane overseen as the encircled magnetic dividers round the edges and by electrical dividers from the head and bottom sides. Since fine substrates area unit used, the fields beneath the patch for normal shapes, as an example, different shapes will be imparted as the summation to actual resounding strategies of 2-dimensional resonator. Bordering fields round edges area unit overseen by extending on the far side what several would contemplate possible outward in order that the persuading estimations area unit more outstanding Then physical estimations of patch. Effect of radiation from radio wire therefore conduit misfortune area unit self-addressed by adding these misfortunes to the misfortune digression of the dielectric substrate. The so much field and transmitted force area unit patterned from the unclear attractive current round at the fringe. Substitute system for joining radiation influence during this model is by demonstrating degree impedance most extreme case at the dividers at opening. Bordering fields therefore diverging power area unit banished within the cavity nevertheless area unit restricted at the sides of the cavity. In any case, the response for the so much field, with consent of admittance dividers is tough to review.

The resonant frequencies in the cavity are:

$$(f_r)_{mnp} = \frac{1}{2\pi\sqrt{\mu\epsilon}}\sqrt{(\frac{m\pi}{h})^2 + \left(\frac{n\pi}{L}\right)^2 + (\frac{p\pi}{W})^2}$$

If L>W>h, the mode with lowest frequency (dominant mode) is TM^{X}_{010}

ConsideringTM_{010},

$$(f_r)_{010} = \frac{1}{2L\sqrt{\mu\epsilon}} = \frac{v_\circ}{2L\sqrt{\mu\epsilon}}$$

Where $v_\circ$ is the speed of the light in free-space

\

2. A COMPACT DUAL BAND MICROSTRIP PATCH ANTENNA

2.1- Introduction

In this chapter, I designed a semicircular with triangular antenna .the designed antenna is operating with three different resonating frequencies. These different frequencies give us the dual band properties. Microstrip line is used as the feeding technique to obtain the desired performance .the need of designing two antennas that operate at two different resonant frequencies reduces with this type of design We can obtain those properties in single design .the antenna is designed with improved impedance bandwidth. ALL the properties are analysed when simulating

2.2- Antenna Geometry

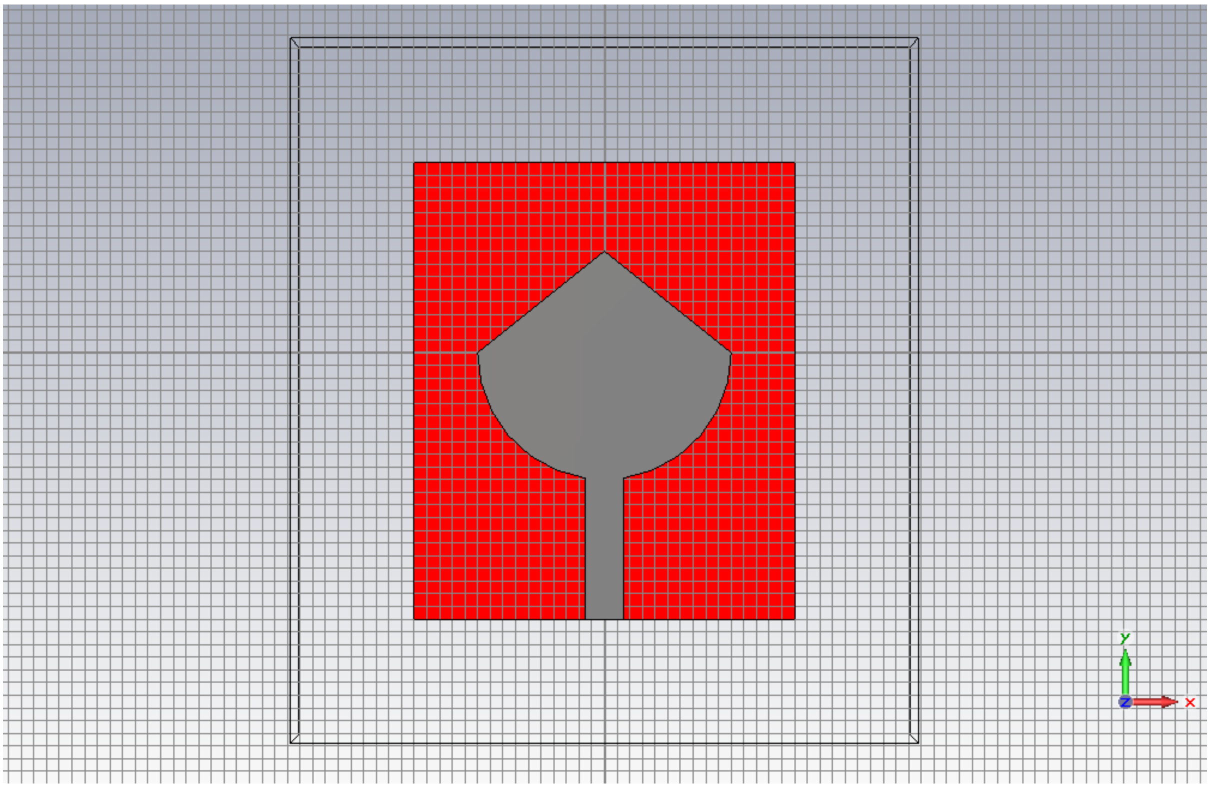
Materials used:

Ground plane: PEC material

Rectangular patch and feed line:PEC material

Substrate material with dielectric constant 4.4

DESIGN



(a) back view

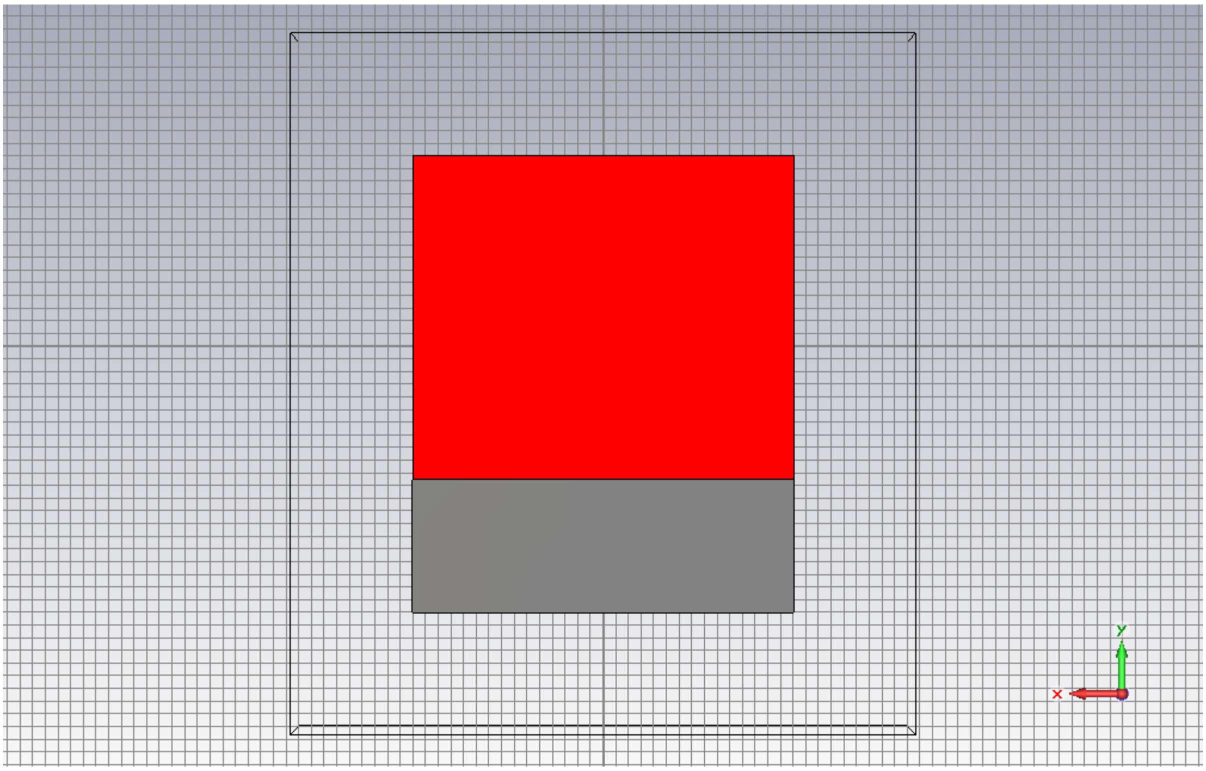


Fig 2.1:-   layout of microstrip patch antenna (a) front view (b) back view

Antenna design parameters:

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For semi circle

• Rad=10mm, Material=PEC , thickness=0.05mm

For triangle

• Height=8mm, width=20mm ,thickness=0.05mm

For substrate-FR4 Material

• Thickness=1.6mm, width=30mm , length=36mm

For Feed line-PEC

• Width=3mm, Length=10.5mm, Thickness=0.05mm

Ground plane

• PEC Material, length=9.5mm, Width=30mm, Thickness=0.05mm

2.3- Results

S-PARAMETER-

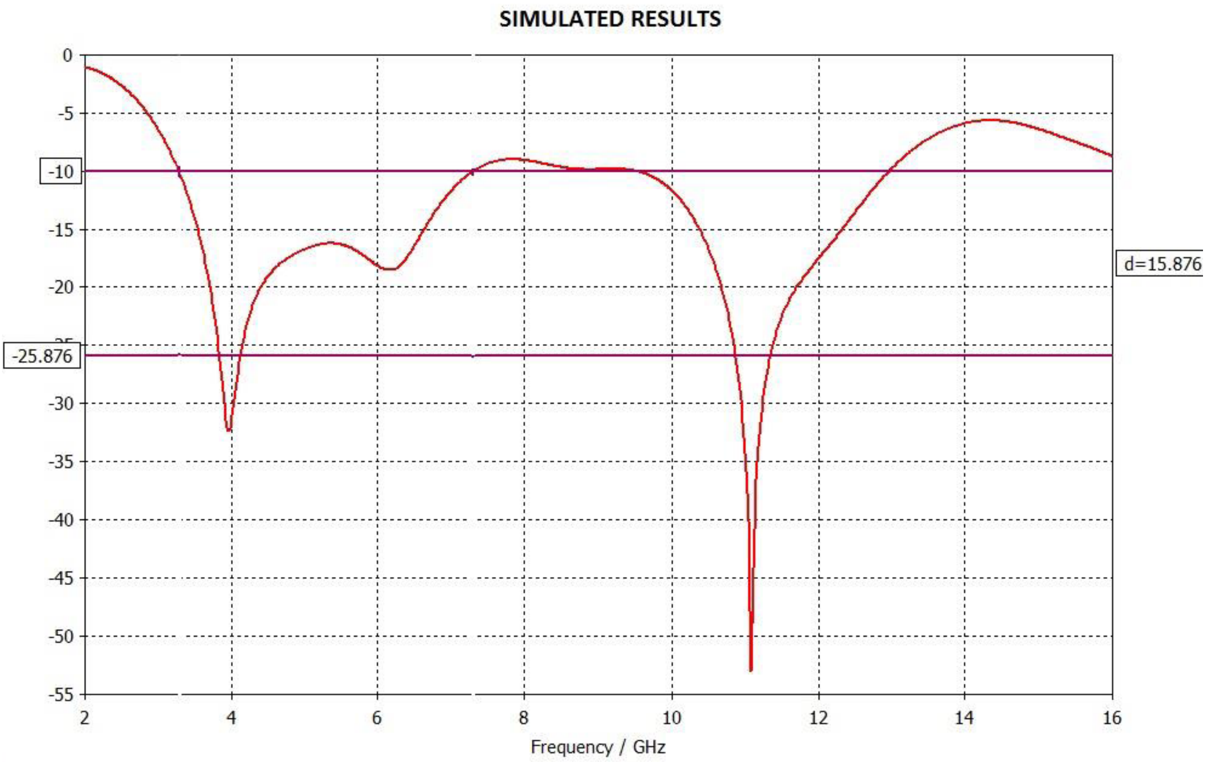


Fig 2.2: Reflection coefficient of compact dual band microstrip antenna

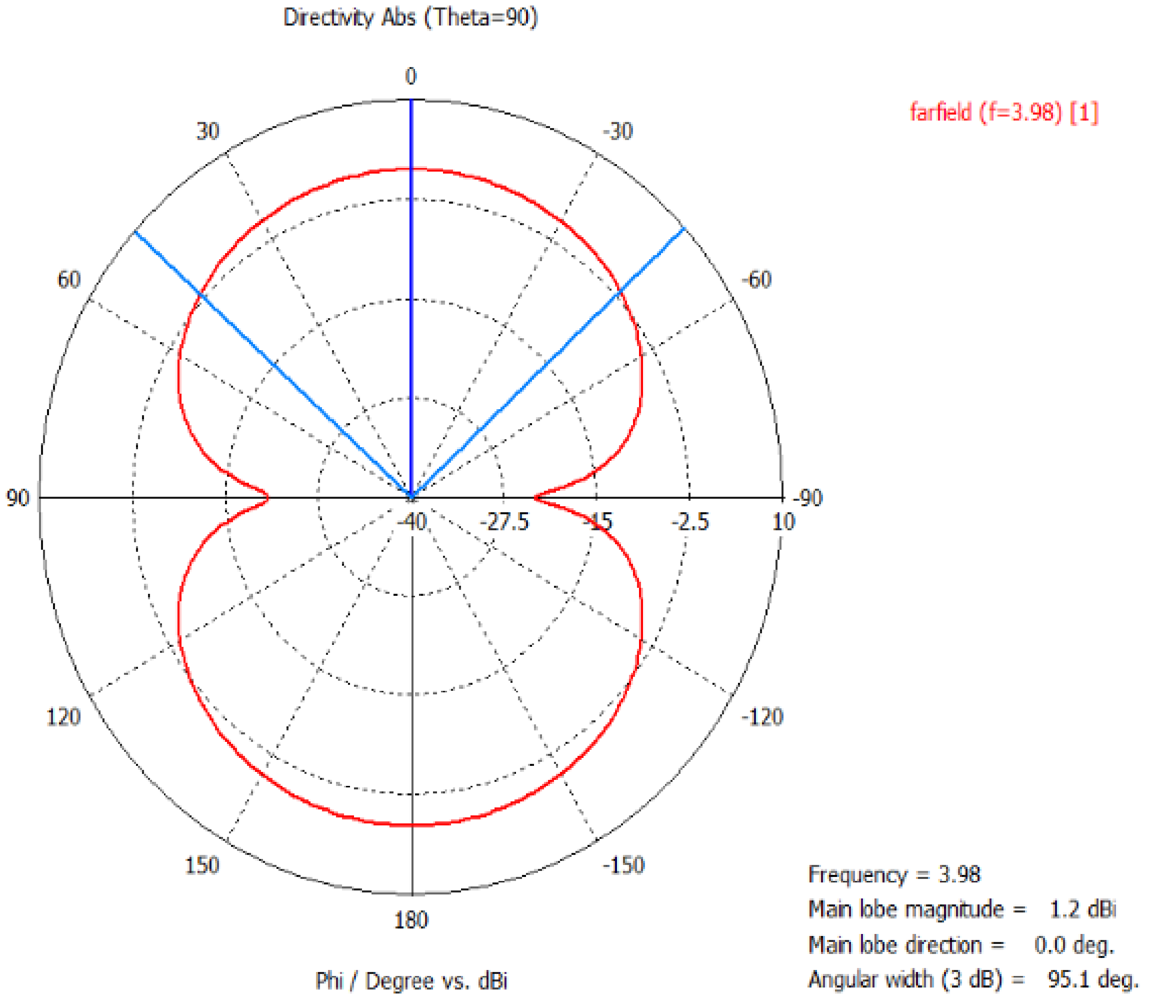
Peak value occurs at

. Resonant frequencies=3.98GHz, 6.28GHz,11.1GHz

2.4 SIMULATED RADIATION PATTERN

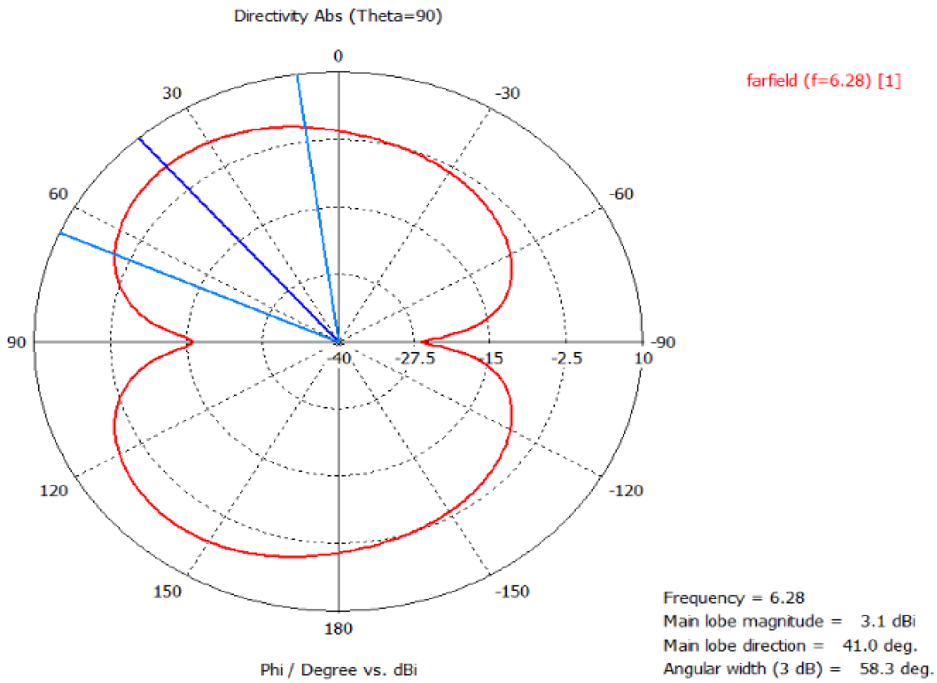
AT (a) 3.98GHz(b) 6.28GHz and (c) 11.1 GHz

E-plane Broad side radiation pattern



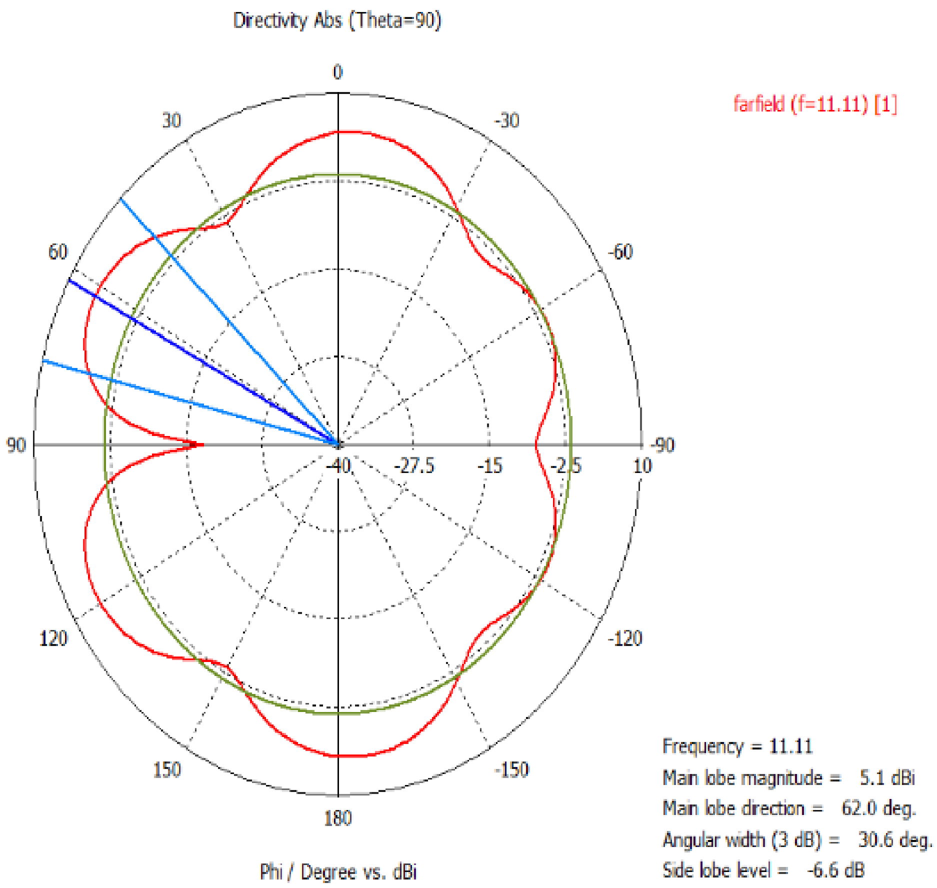
Directivity Abs (Theta=90)
farfield (f=3.98) [1]
0
30
-30
60
-60
90
-90
-40
-27.5
-15
-2.5
10
120
-120
150
-150
180
Phi / Degree vs. dBi
Frequency = 3.98
Main lobe magnitude = 1.2 dBi
Main lobe direction = 0.0 deg.
Angular width (3 dB) = 95.1 deg.

(b) 6.28GHz



Directivity Abs (Theta=90)
farfield (f=6.28) [1]
0
30
-30
60
-60
90
-90
-40
-27.5
-15
-2.5
10
120
-120
150
-150
180
Phi / Degree vs. dBi
Frequency = 6.28
Main lobe magnitude = 3.1 dBi
Main lobe direction = 41.0 deg.
Angular width (3 dB) = 58.3 deg.

(c) 11.1 GHz



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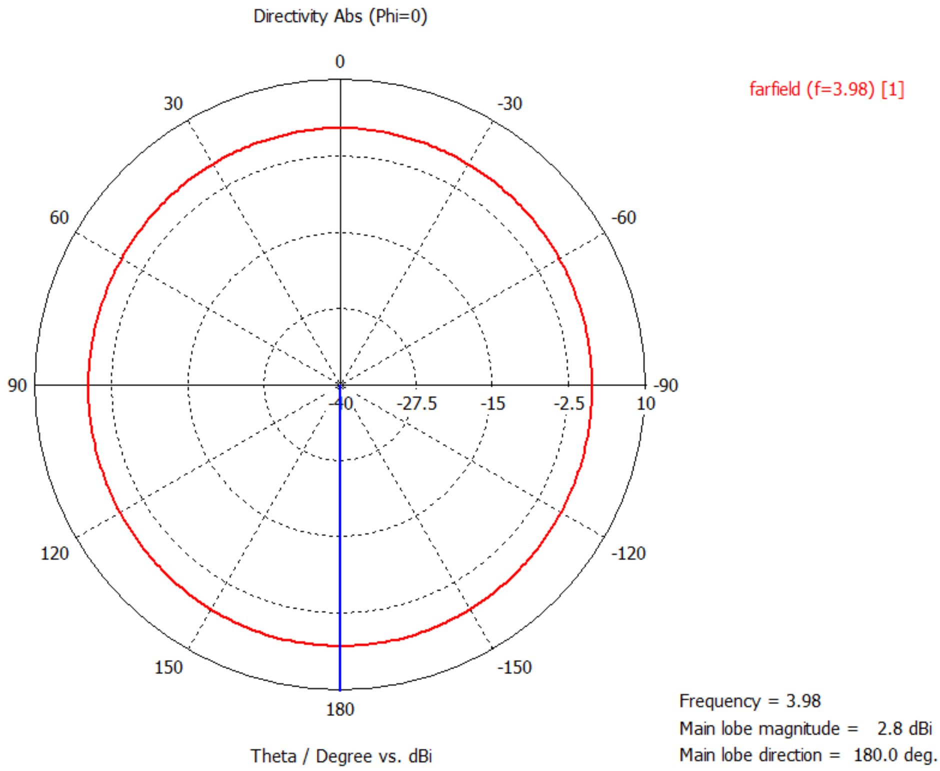
H-plane omnidirectional radiation pattern-

(a) 3.98GHz



(b)

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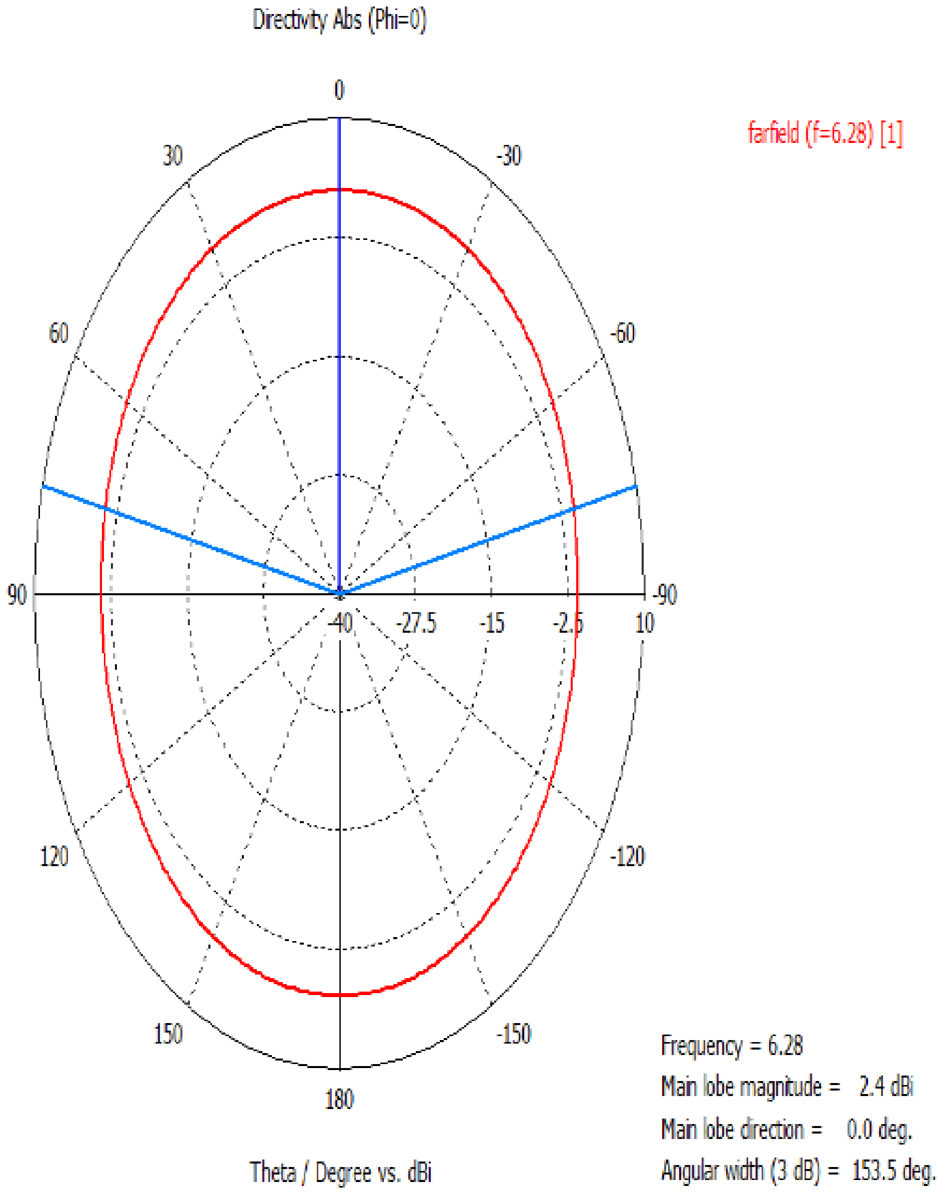
6.28GHz


Directivity Abs (Phi=0)
0
30
-30
60
-60
90
-90
120
-120
150
-150
180
-40
-27.5
-15
-2.5
10
farfield (f=6.28) [1]
Frequency = 6.28
Main lobe magnitude = 2.4 dBi
Main lobe direction = 0.0 deg.
Angular width (3 dB) = 153.5 deg.
Theta / Degree vs. dBi

(c) 11.1 GHz

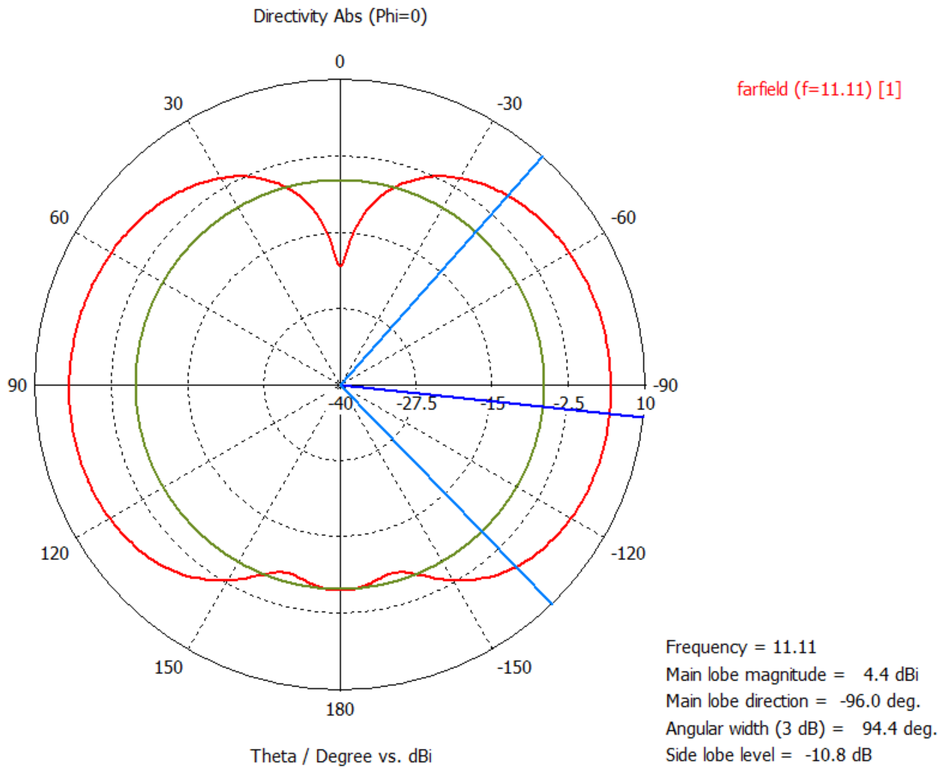
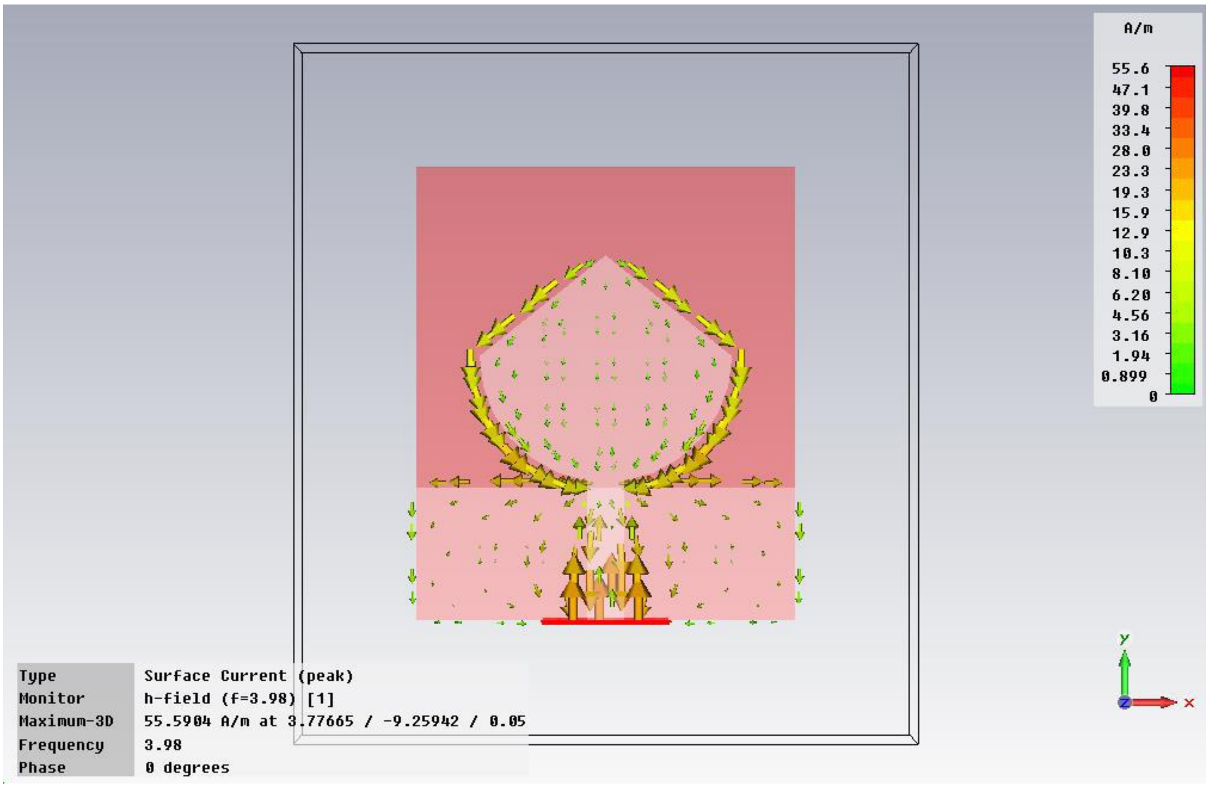


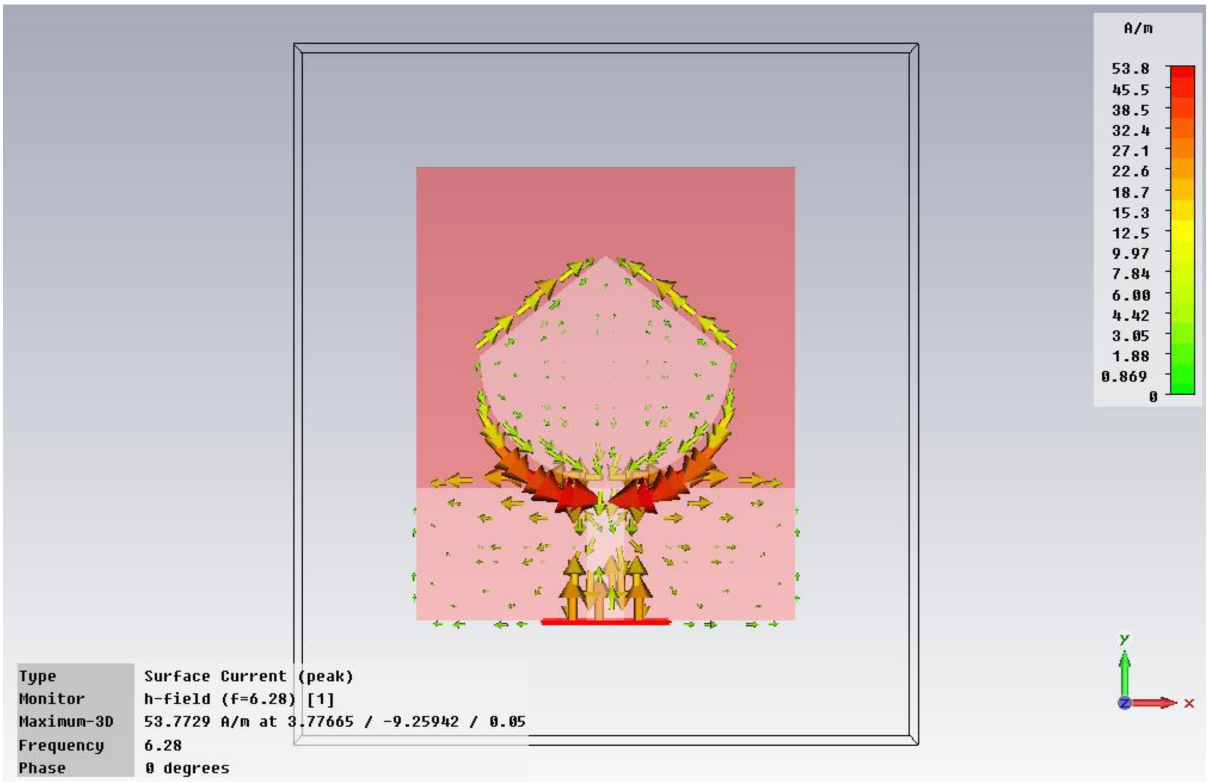
Fig 2.3: Radiation pattern of compact dual band microstrip antenna at different resonant frequencies

2.5 SURFACE CURRENT DISTRIBUTION

(a) 3.98GHz



(b) 6.28GHz



(c) 11.1 GHz

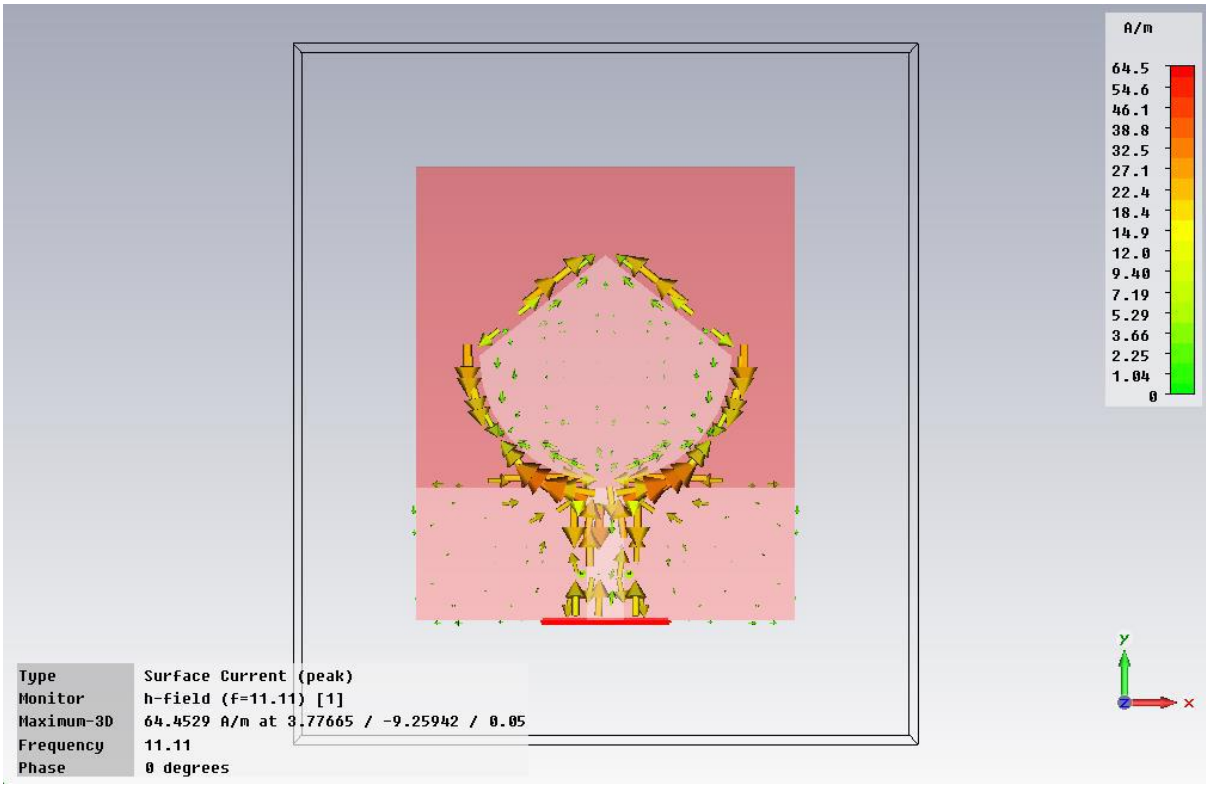


Fig 2.4: Surface current distribution of compact dual band microstrip antenna

GAIN-

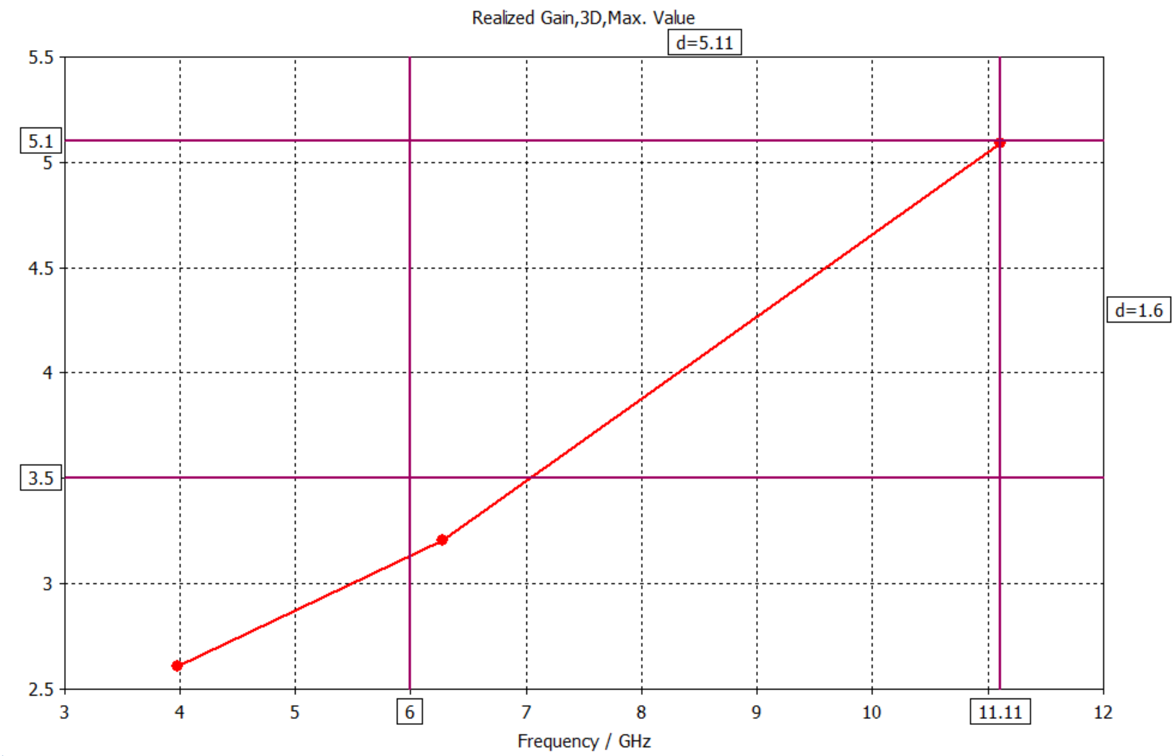


Fig 2.5: Gain of compact dual band microstrip antenna

DIRECTIVITY

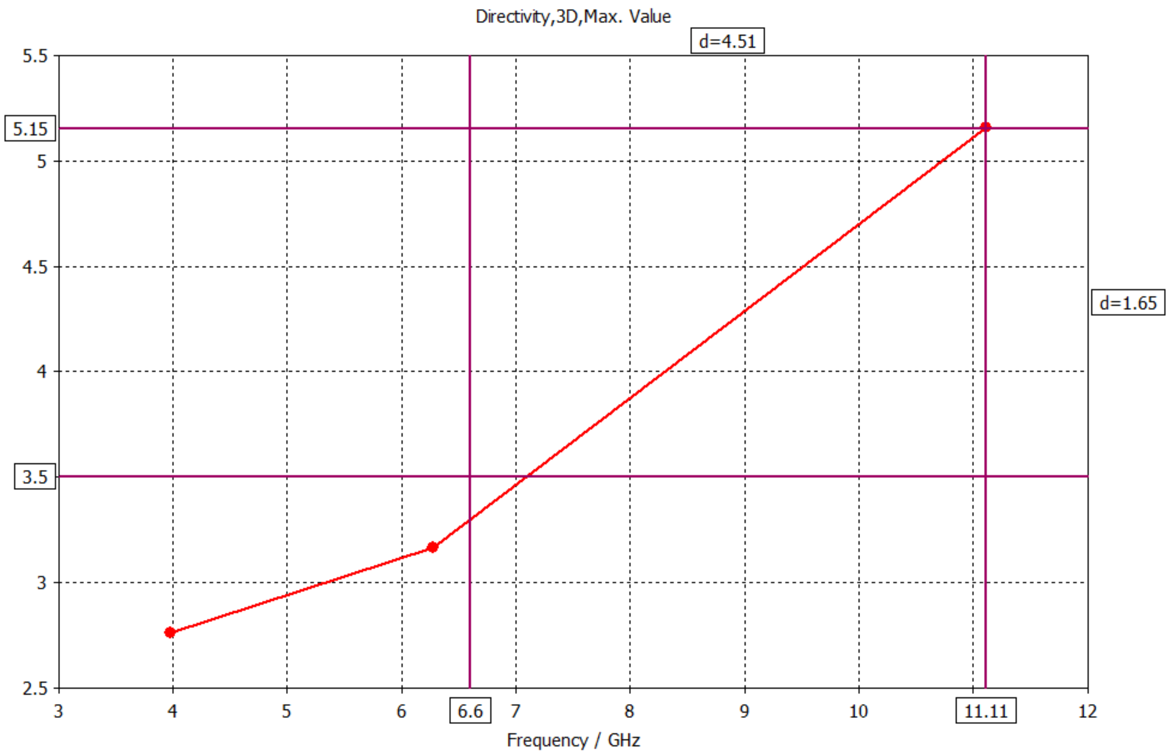
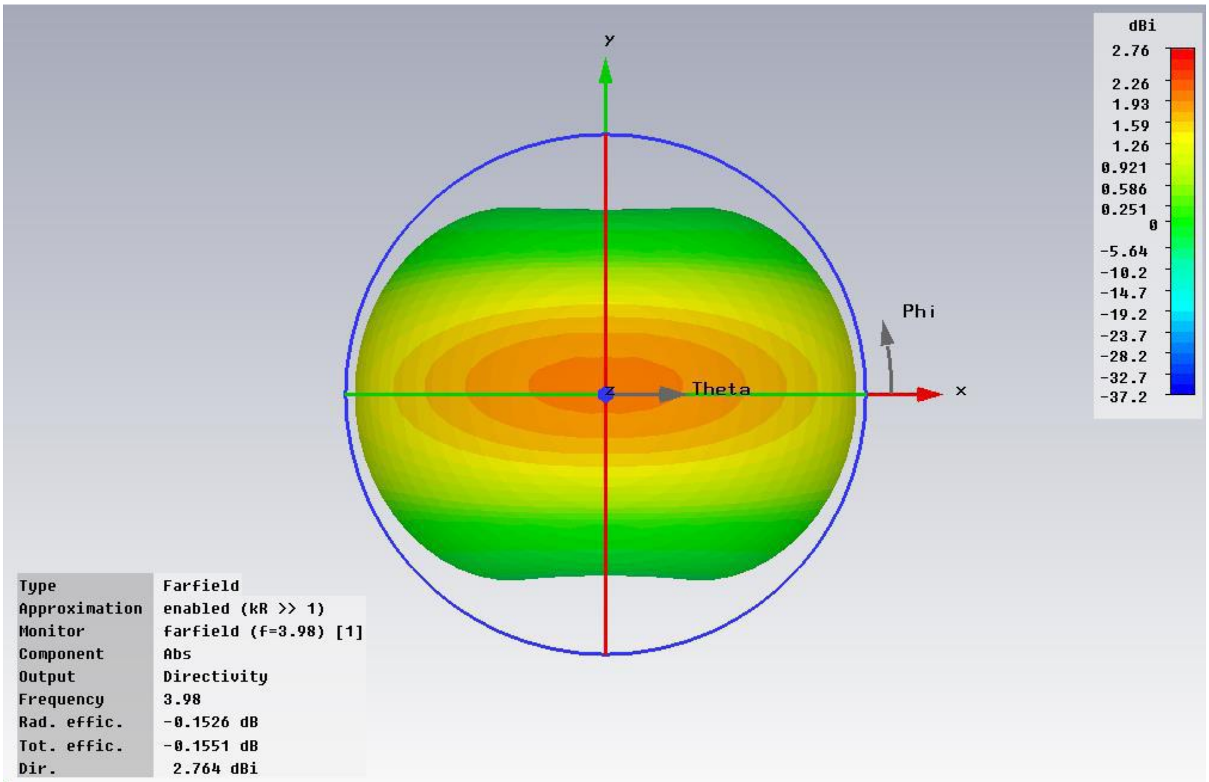


Fig 2.6: Directivity of compact dual band microstrip antenna

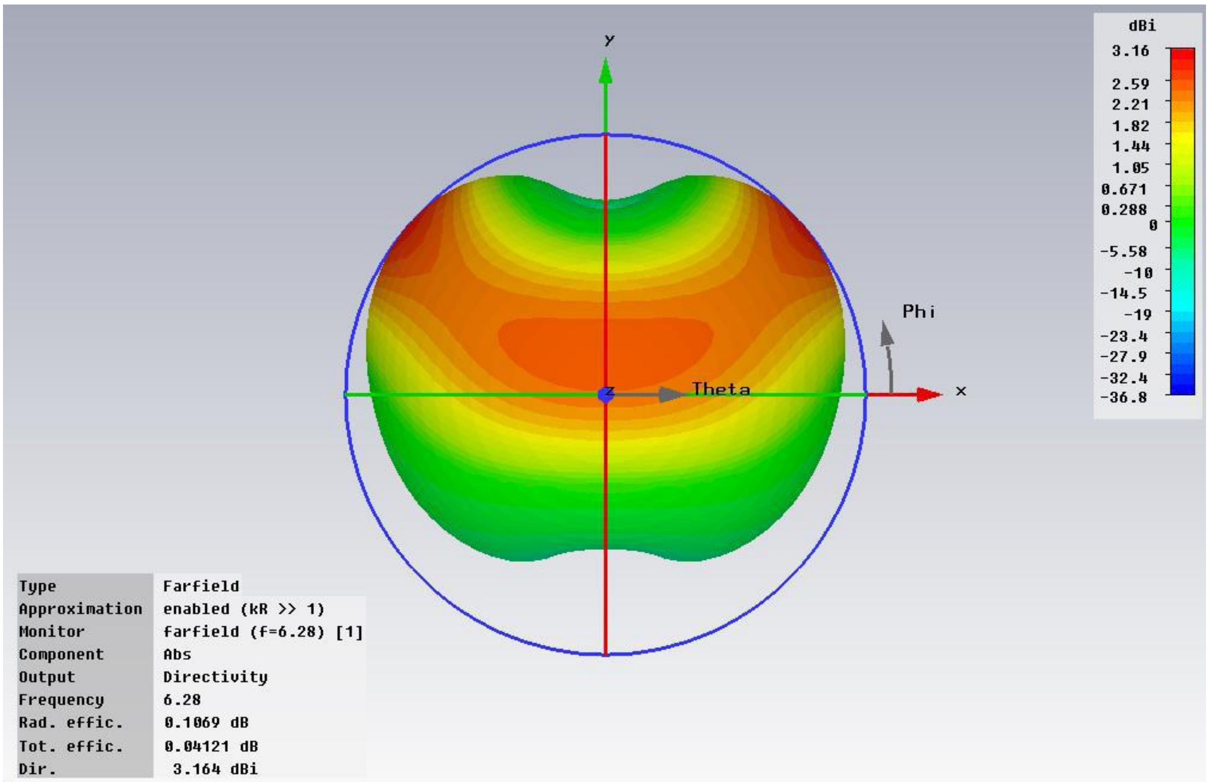
2.6 SIMULATED 3D PATTERN

(a) 3.98GHz



*(*b)

6.28GHz



(*c*) 11.1 GHz

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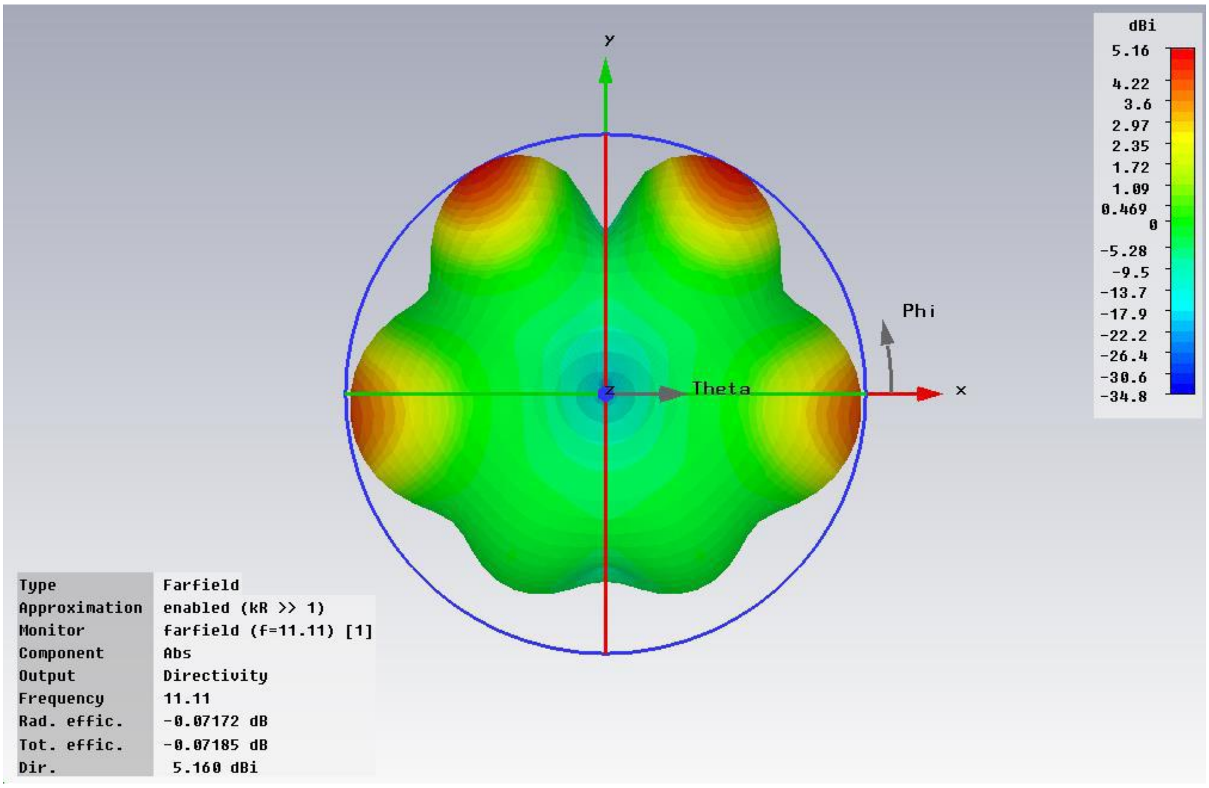

Fig 2.7: Simulated 3D Pattern compact dual band microstrip antenna

2.8 CONCLUSIONS

A semicircular with triangular shape antenna was designed.

Resonating frequencies are obtained at 3.98GHz , 6.28GHzand 11.11GHz

Maximum realised gain of 5.1db achieved

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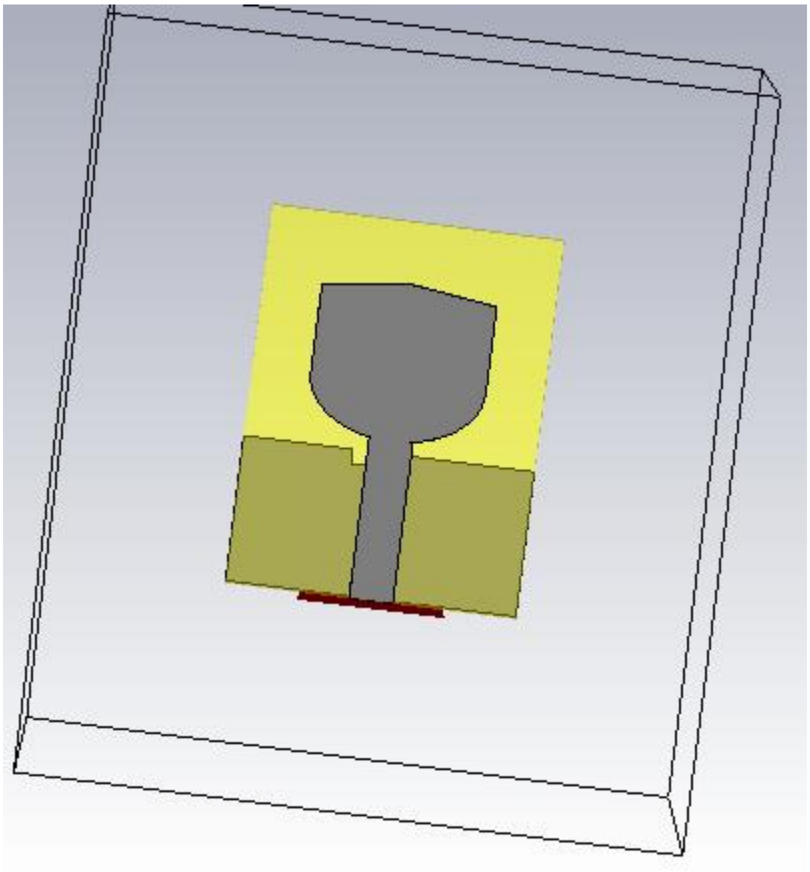
3.A COMPACT WIDEBAND MICROSTRIP ANTENNA

3.1- Introduction

A compact wideband microstrip patch antenna is designed and discussed. Right once a antenna should work on two different frequencies that ar way apart, a multiple frequency antenna are often utilised to the utilization of two distinctive antennas. Once two a lot of resonating frequencies of a MSA ar near one another, a good war is procured. Precisely once this ar separated, twofold band operation is gotten. With everything taken into consideration, all the schedules depicted before for extending the BW of MSAs are often utilised to urge double band attributes. In various plans, either electromagnetic coupling may be used for double band operation.

3.2- Antenna Geometry

(a) Front view



(b) Back view

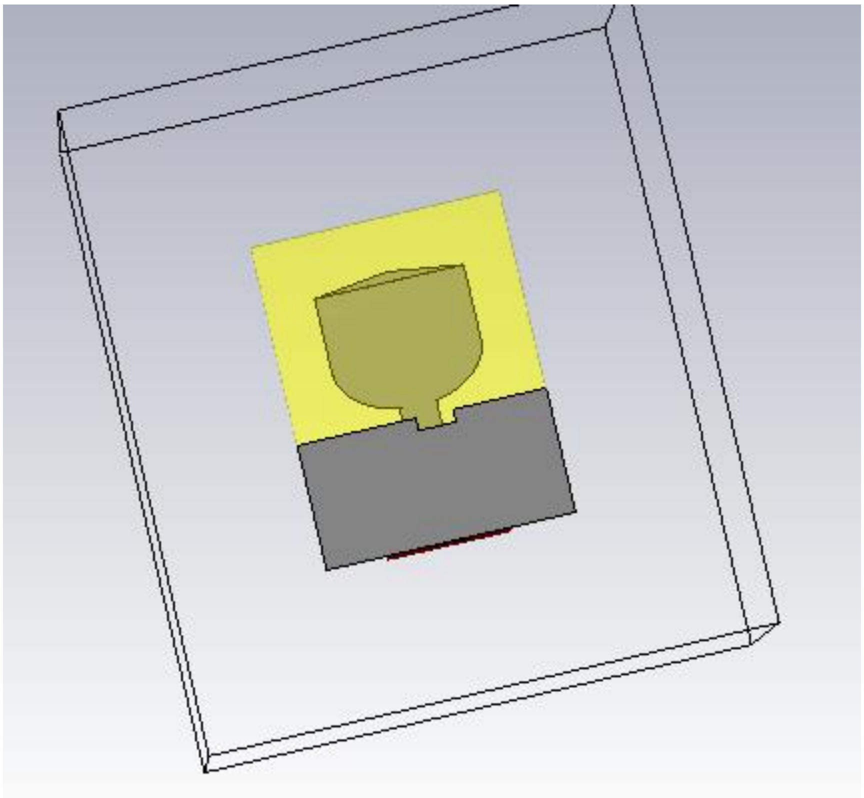


Fig 3.1: proposed antenna geometry

Materials used:

Ground plane: PEC material

Rectangular patch and feed line:PEC material

Substrate material with dielectric constant 4.4

W1=20mm, L1=26mm, Wg=8mm, Lf=10.8mm, Ls=1.8mm, d=0.05mm, Wf=4mm, ε_r=4.4, W=12mm, L=6mm, h=1.6mm

Triangular section (base=12mm, height=0.8mm)

Rectangular section (W=12mm, L=6mm)

Semi-elliptical section(X-radius = 6mm, Y-radius =4mm)

3.3- Results

Return Loss

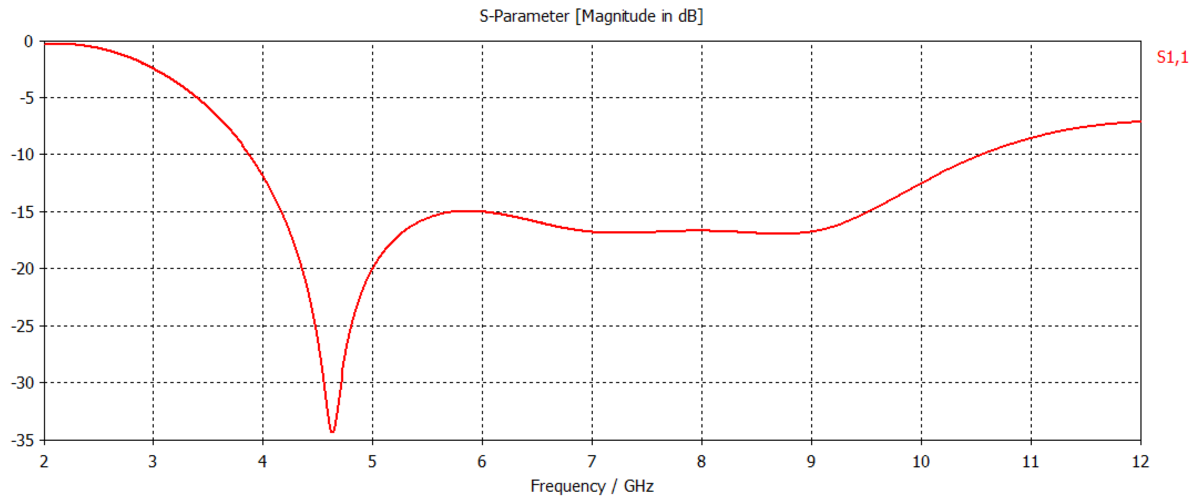


Fig 3.2 : Reflection coefficient of compact Wideband microstrip antenna

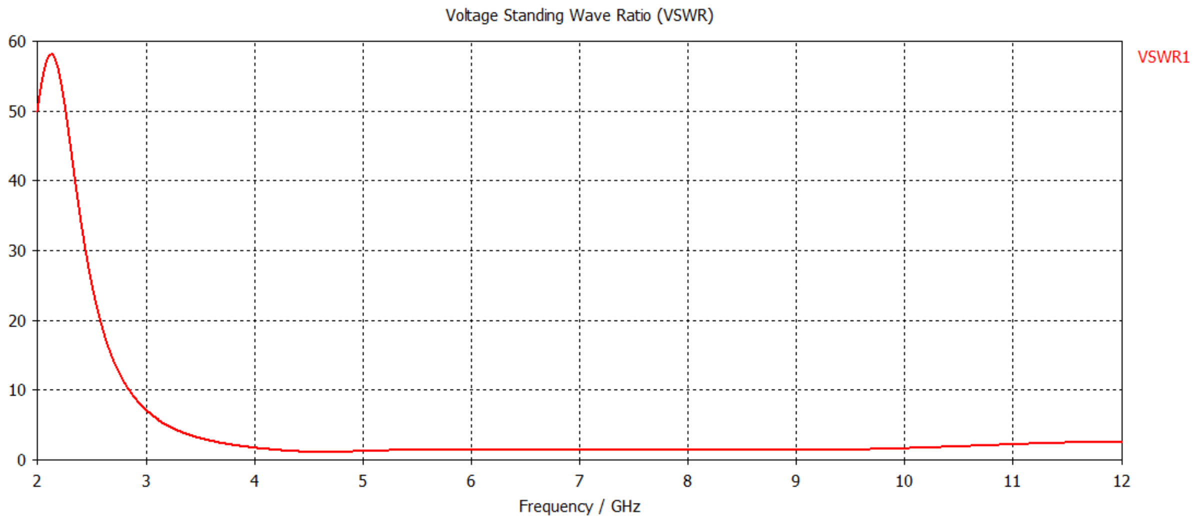
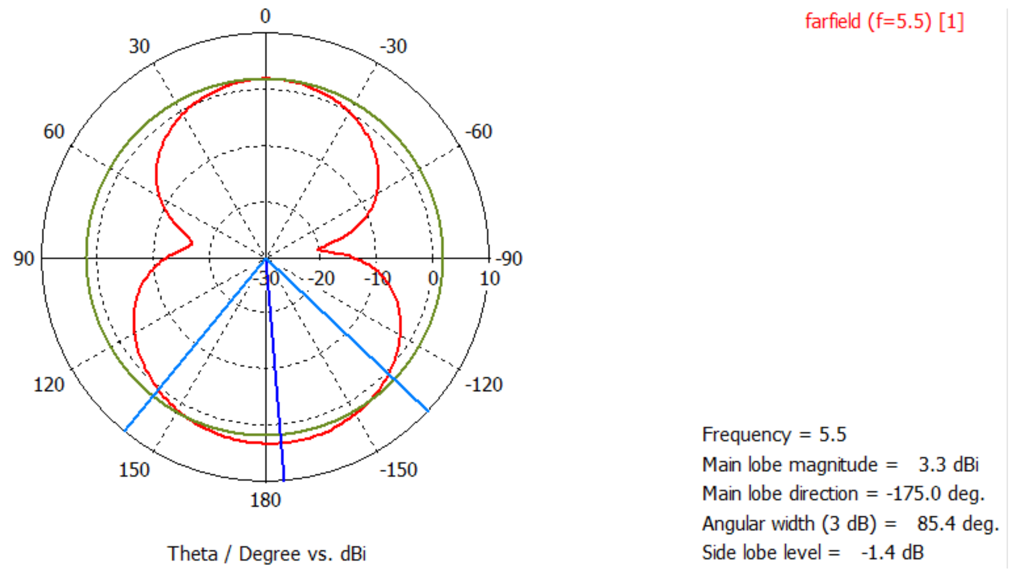


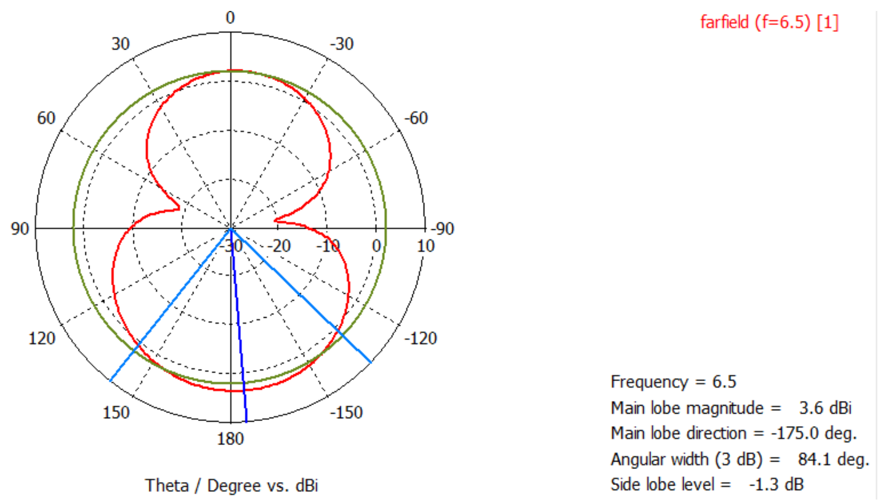
Fig 3.3:VSWR plot of compact Wideband microstrip antenna

3.4 SIMULATED RADIATION PATTERN

At (a) 5.5GHz(E plane and H plane)



At (b) *6.5GHz*



(c)10.5Ghz

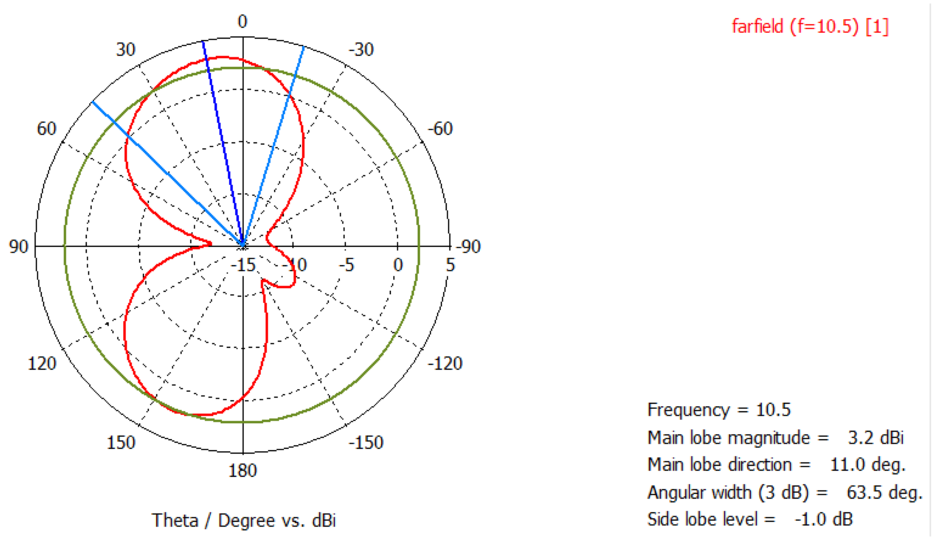
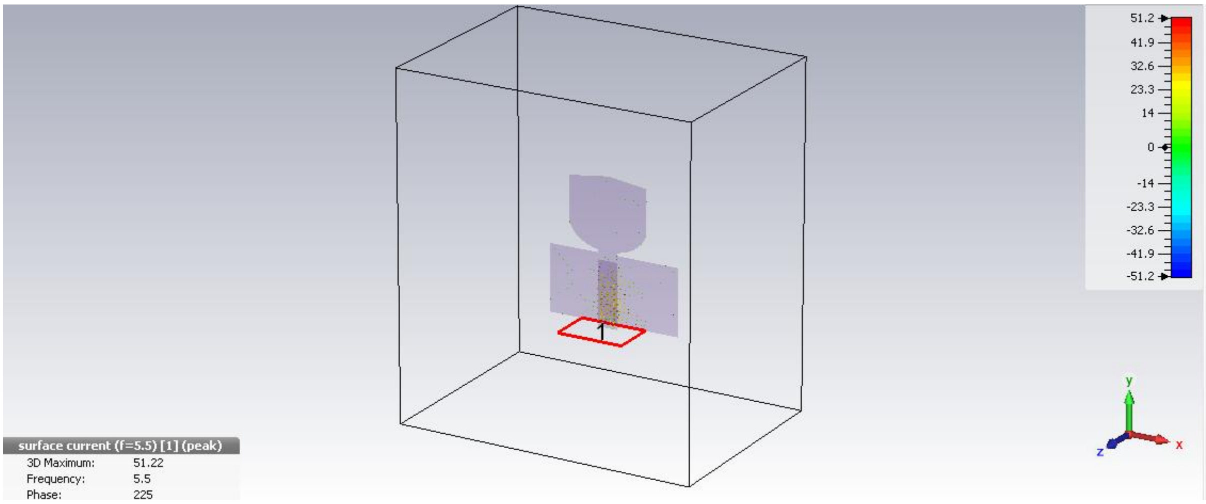


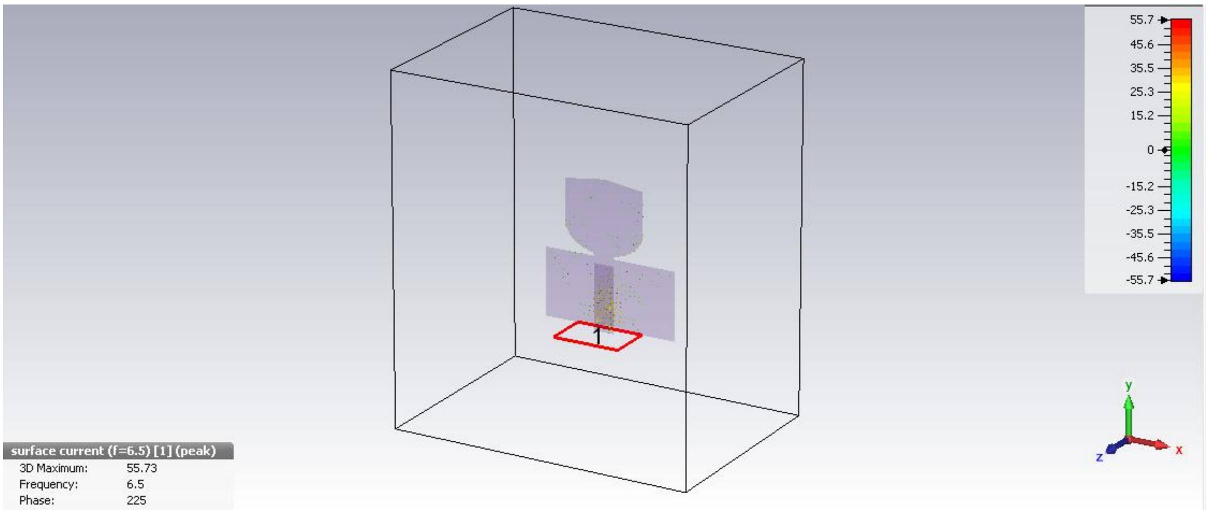
Fig 3.4: Radiation pattern of compact wide band microstrip antenna

3.5 SURFACE CURRENT DISTRIBUTION

At (a) 5.5GHz



(b) ***6.5GHz***



(c)9.5GHz

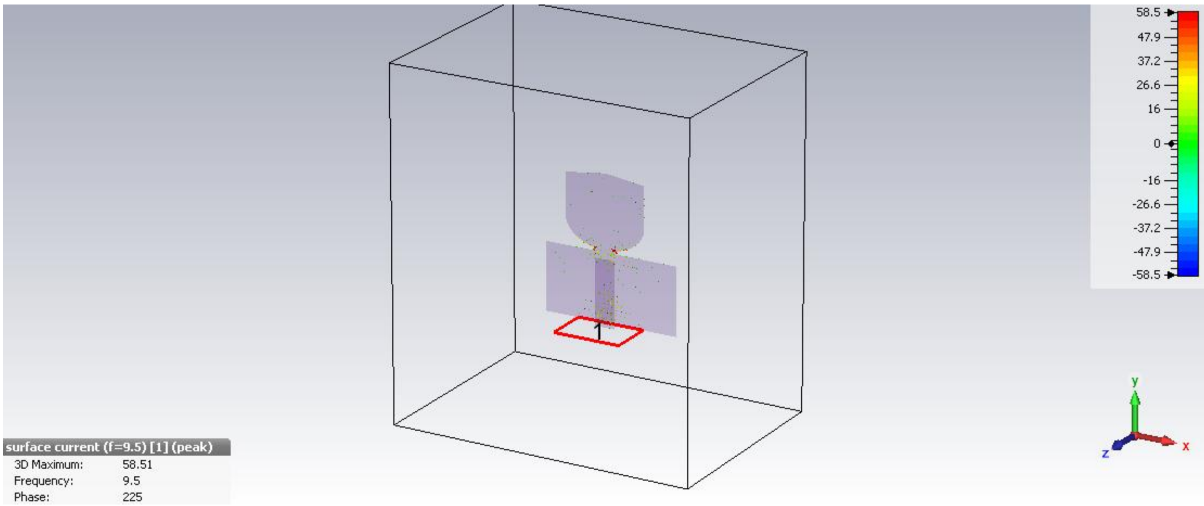
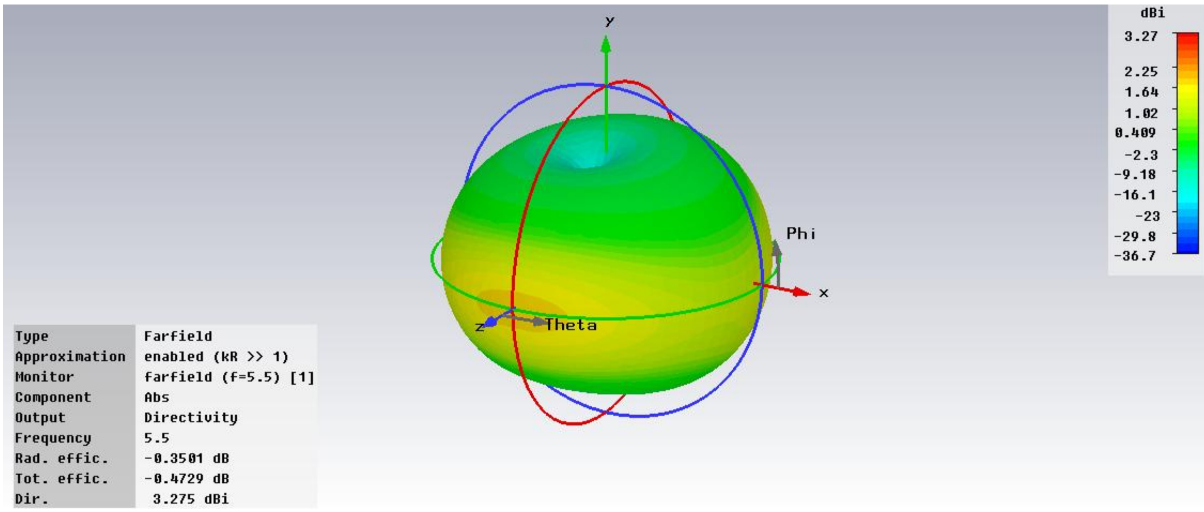


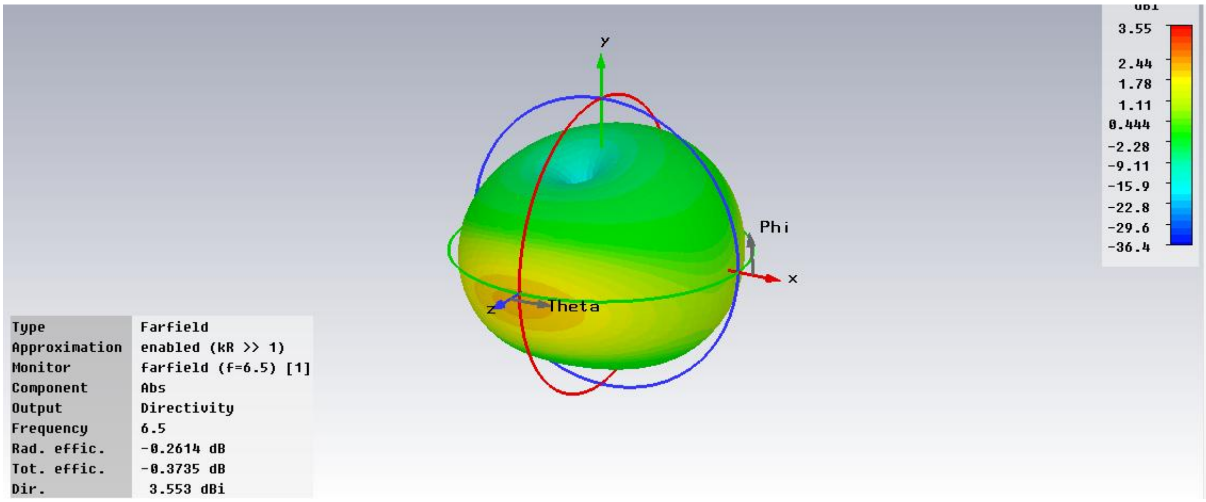
Fig 3.5: surface current distribution of compact wide band microstrip antenna

3.6 SIMULATED 3D PATTERN

(a)5.5GHz



(b)6.5GHz



(c)10.5GHz

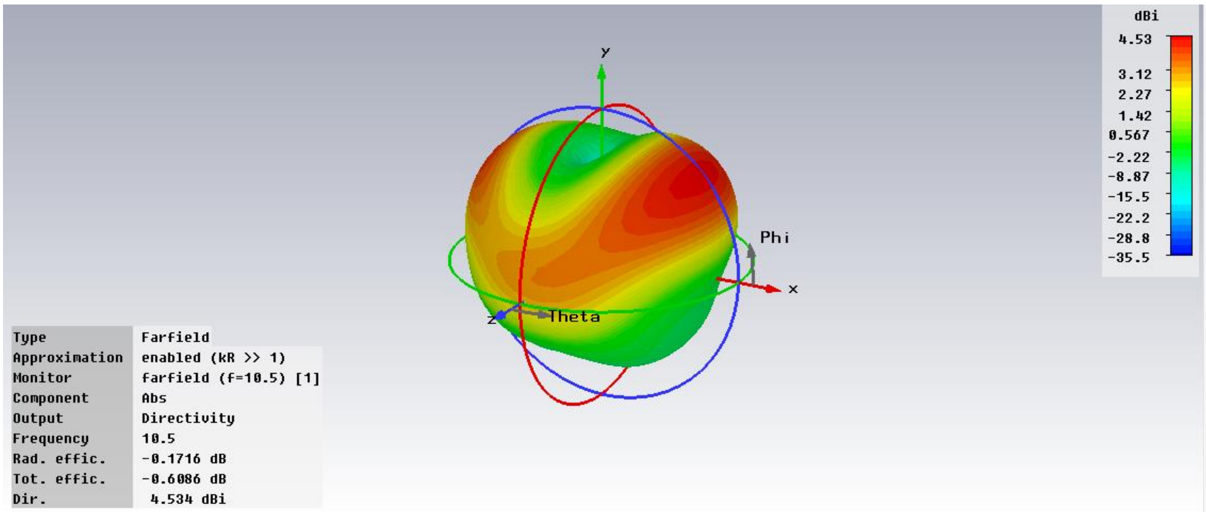
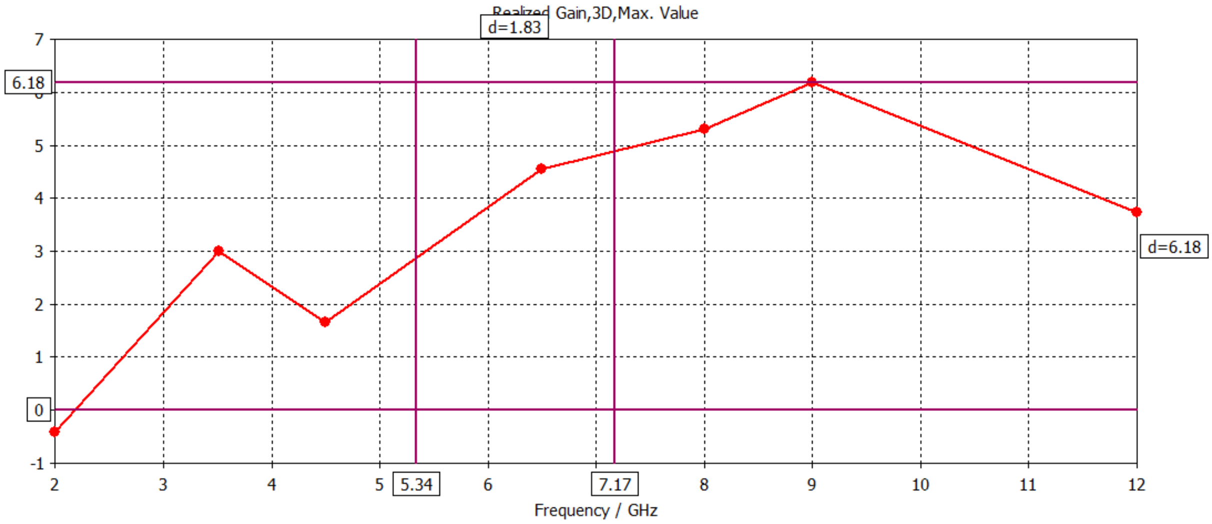
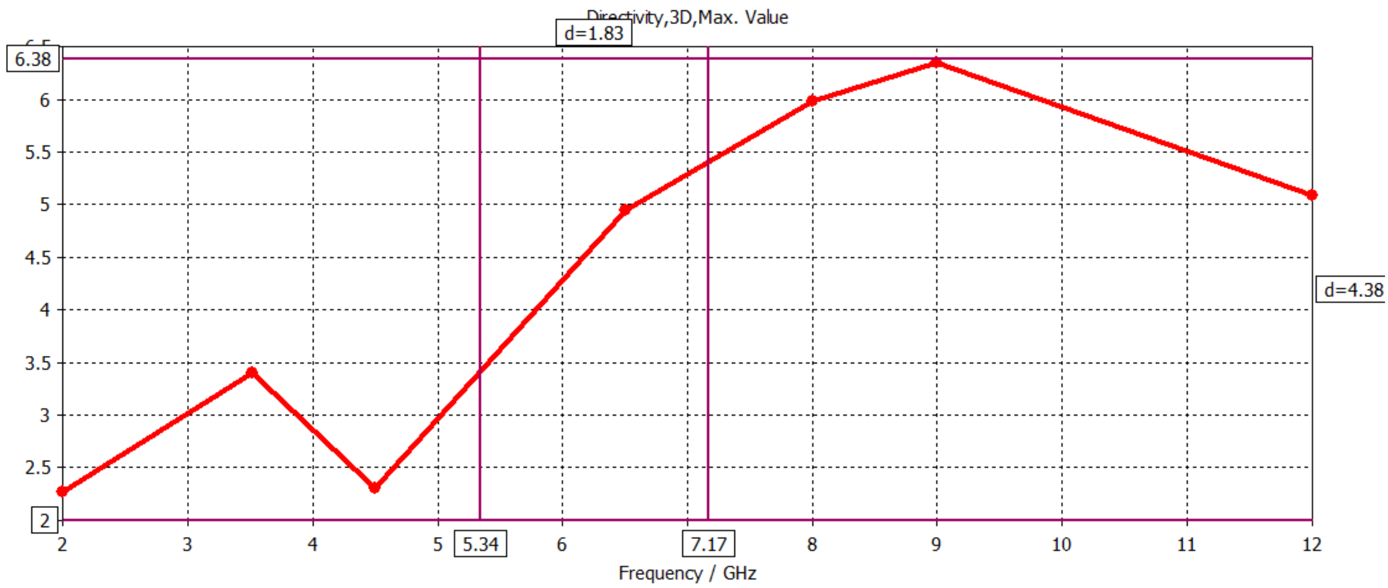


Fig 3.4:Simulated 3D pattern

3.7 GAIN PLOT



3.8 Directivity



3.9- Conclusion

.In this prototype A wideband microstrip patch antenna was Put forward. The microstrip antenna patch was excited by microstip feedline technique.The designed antenna has bandwidth from 3.8 to 10.5 GHz. The obtained gain is 6.18 db.The directivity is 6.38 dB.

CHAPTER 4

Study of a Printed Circular Disc Monopole Antenna for UWB Systems

4.1Introduction

Recently, a number of broadband monopole arrangements, for instance, round, square, circular, hexagonal and an pentagonal shapes are projected for UWB applications. These broadband monopoles highlight wide operating data transmissions, appropriate radiation properties, simple structures and ease of manufacture. Be that as it may they're not planar structures in light-weight of the actual fact that their ground planes are opposite to the radiators. Therefore, they're not appropriate for coordination with a imprint on a circuit board

A printed circular disc monopole fed by microstrip line is put forward. The parameters that have an effect on the operation terms of the antenna in of its frequency domain characteristics are analysed. the optimum style of this kind of Antenna are able to do an ultra wide bandwidth with satisfactory radiation properties the simulations have conjointly shown that the projected monopole antenna is nondispersive, that is extremely vital for UWB systems.

4.2- Antenna Geometry

Materials used:

Ground plane: PEC material

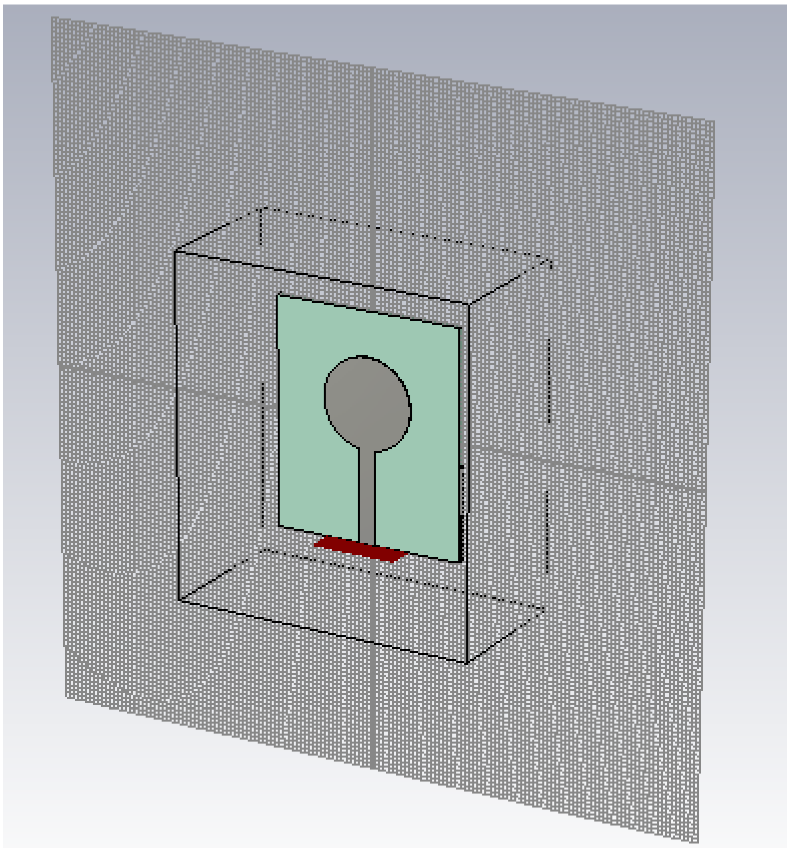
Rectangular patch and feed line: PEC material

Substrate material with dielectric constant 4.4

r = 10 mm, h = 0:3 mm, W = 42 mm, and L = 50 mm

.

(a) Front view



(b) Back view

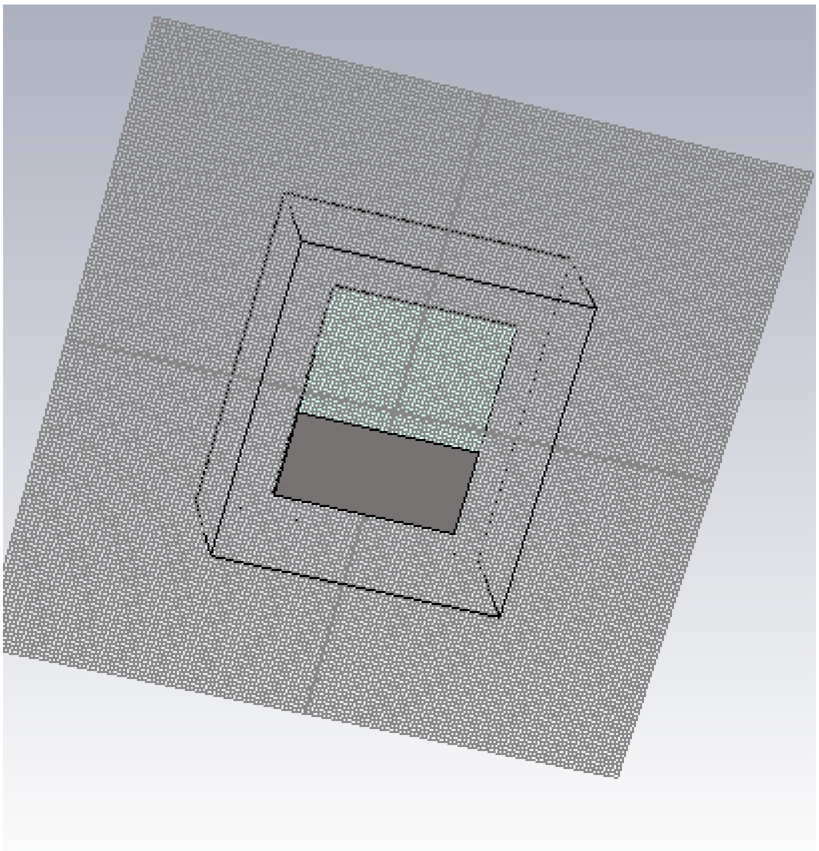


Fig 4.1 Proposed antenna geometry

4.3RESULTS

Simulated and Measured Returnloss curves

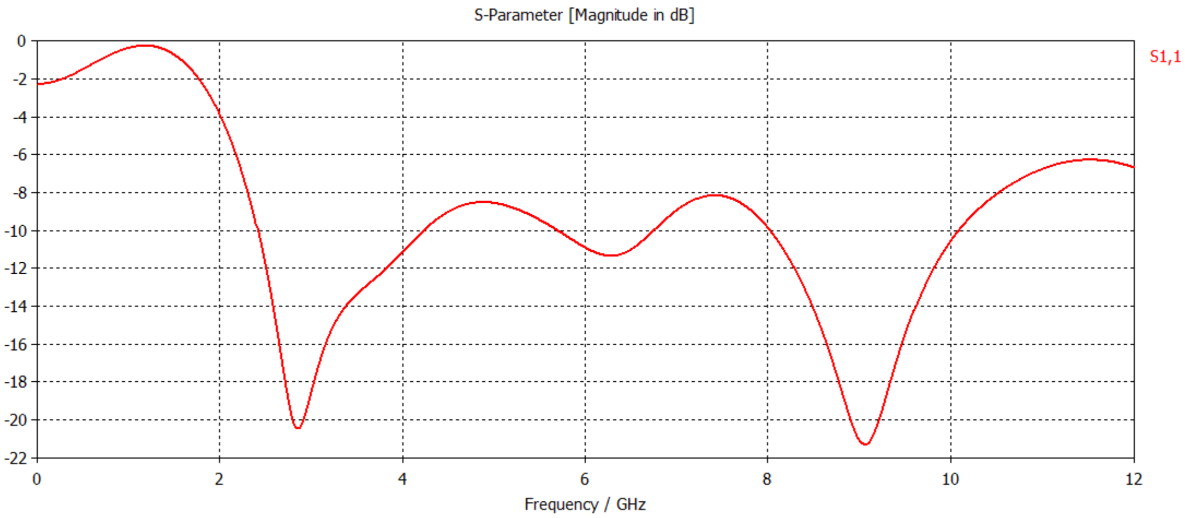


Fig 4.2 returnloss curve

VSWR plot of compact Wideband microstrip antenna

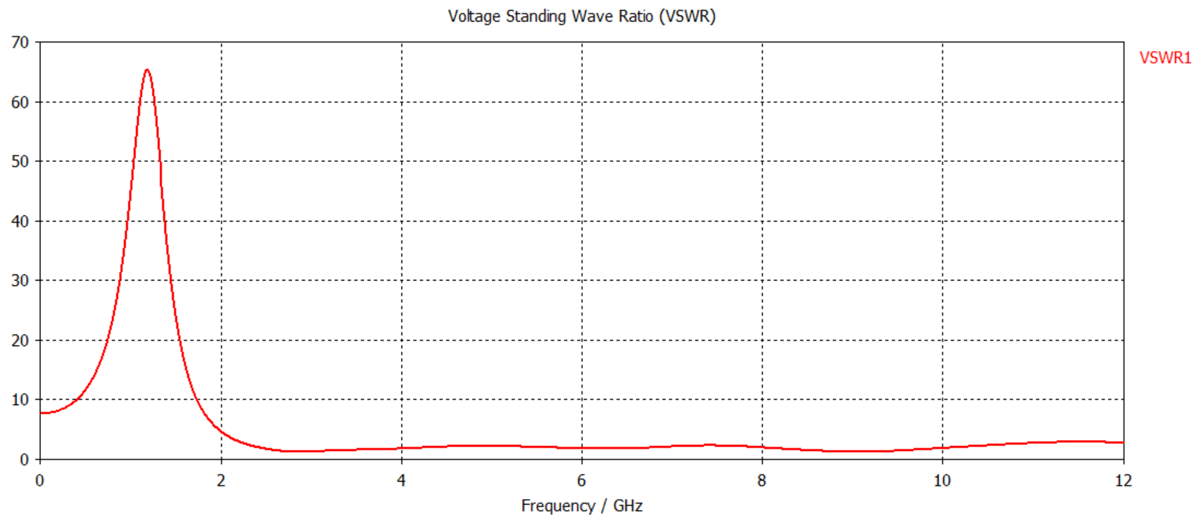
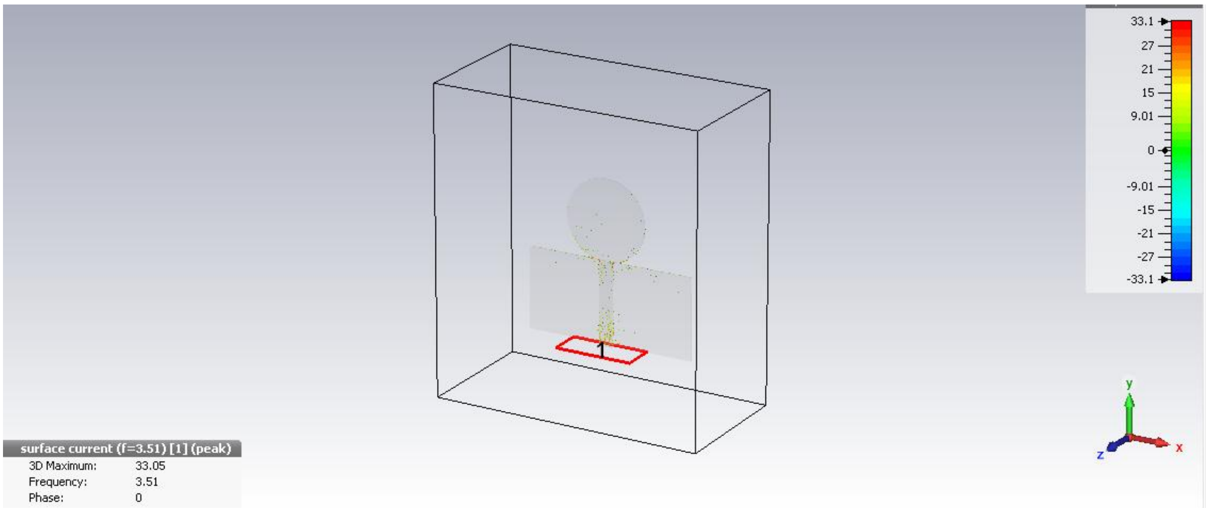


Fig 4.3 vswr plot

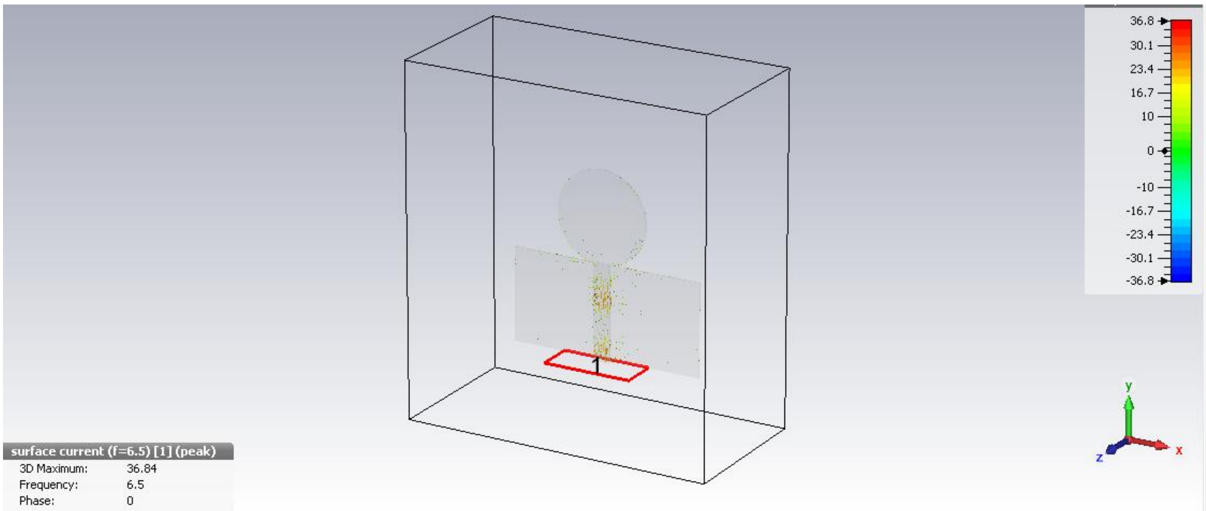
4.4 ANTENNA CHARACTERISTICS

A. Surface Current Distributions

(a)3.51GHz



(b)6.5GHz



(c)9GHz

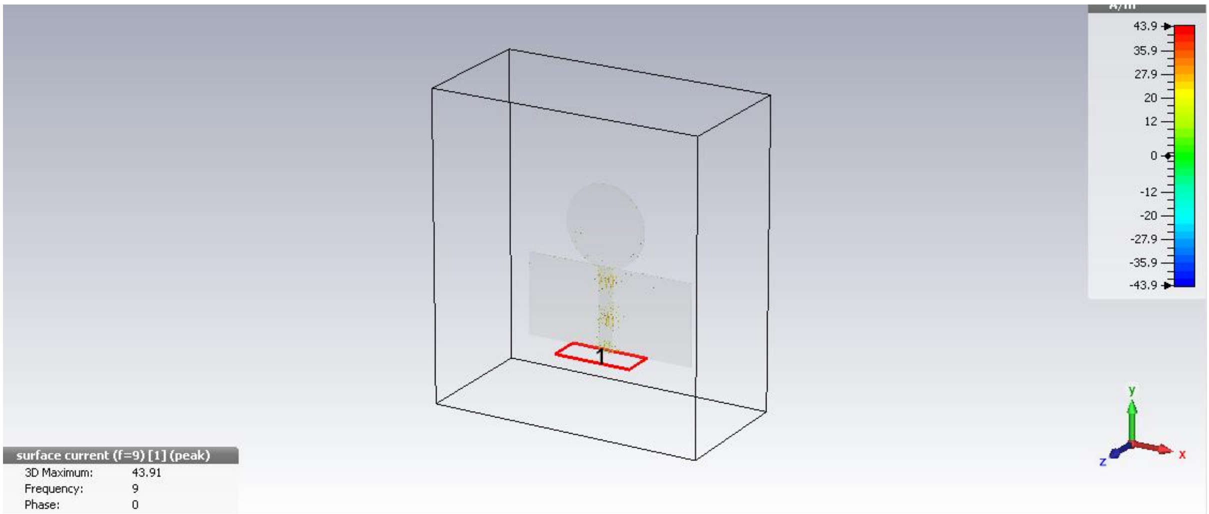


Fig 4.4 surface current distributions

B. The Effect of the Dimension of the Disc

Simulated return loss curves for different dimensions of the circular disc with their respective optimal designs(r=10mm with h=0.3mm,W=42mm and L=50mm and r=12.5mm with h=0.3mm,W=50mm and

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L=50mm and r=15mm with h=0.3mm,W=57mm and L=60mm and r=20mm with h=0.4mm,W=75mm and L=75mm

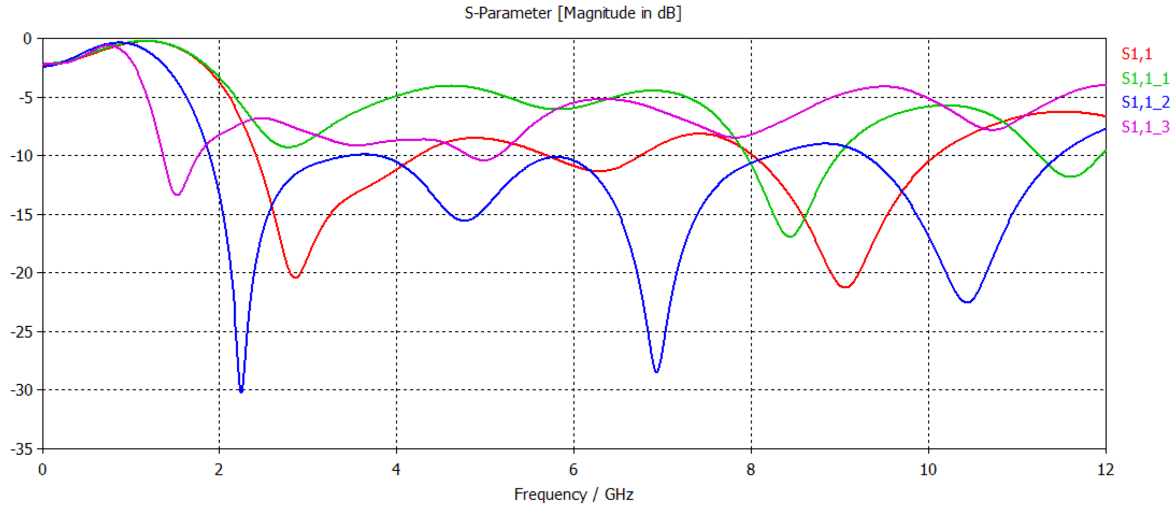
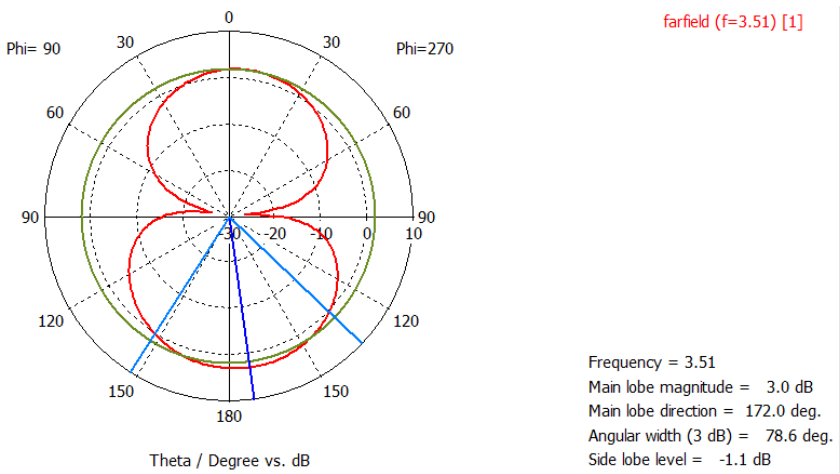


Fig 4.4 Simulated return loss curves for different dimensions of the circular disc with the optimal designs

4.5 SIMULATED RADIATION PATTERN

(a)3.51GHz



(b)6.5GHz

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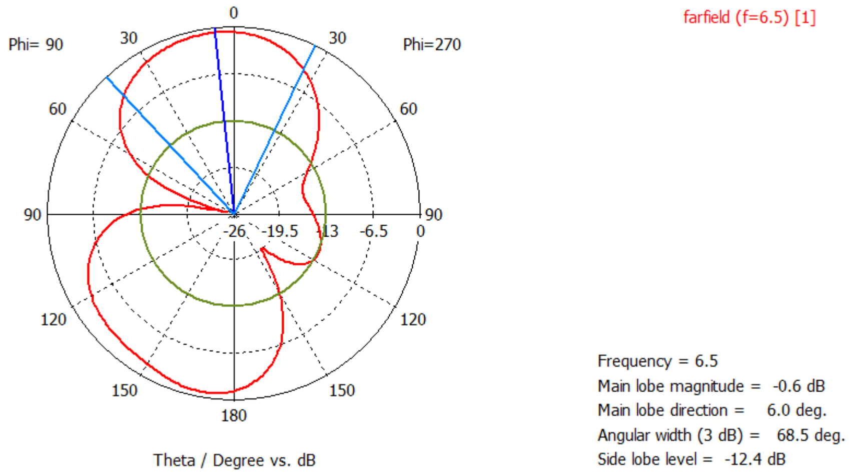


(c) 9 GHz

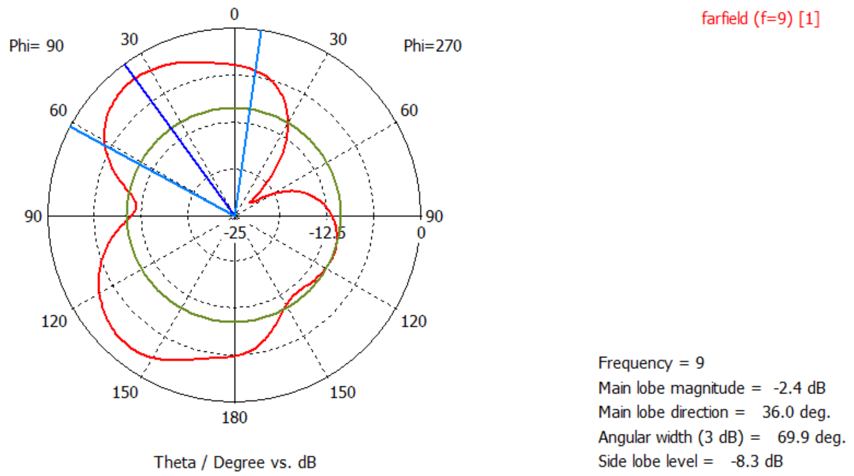
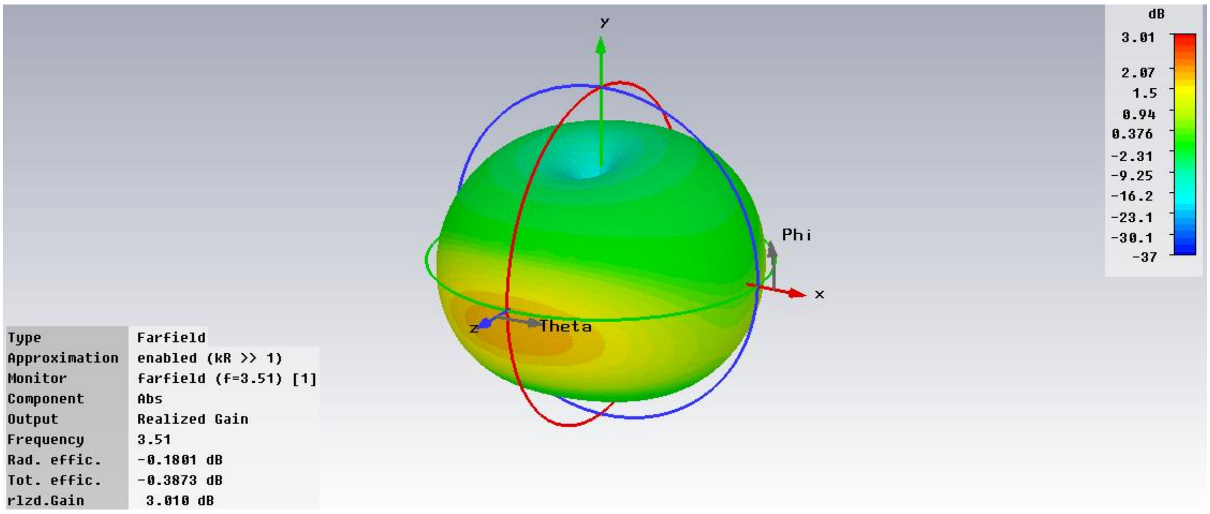


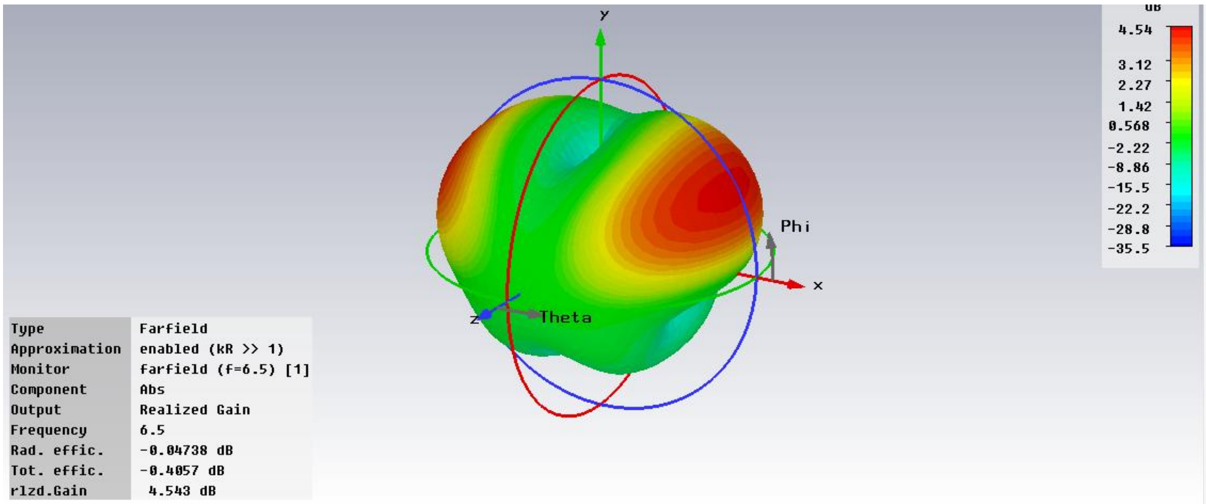
Fig 4.5 Radiation Patterns

4.6 SIMULATED 3D PATTERN

(a)3.51GHz



(b)6.5GHz



(d)9GHz

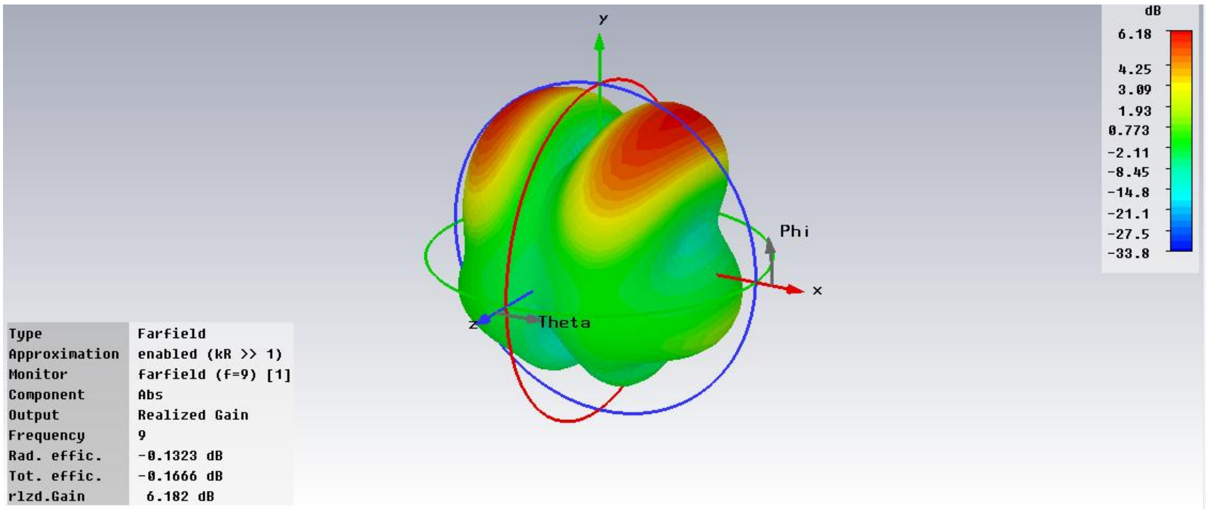
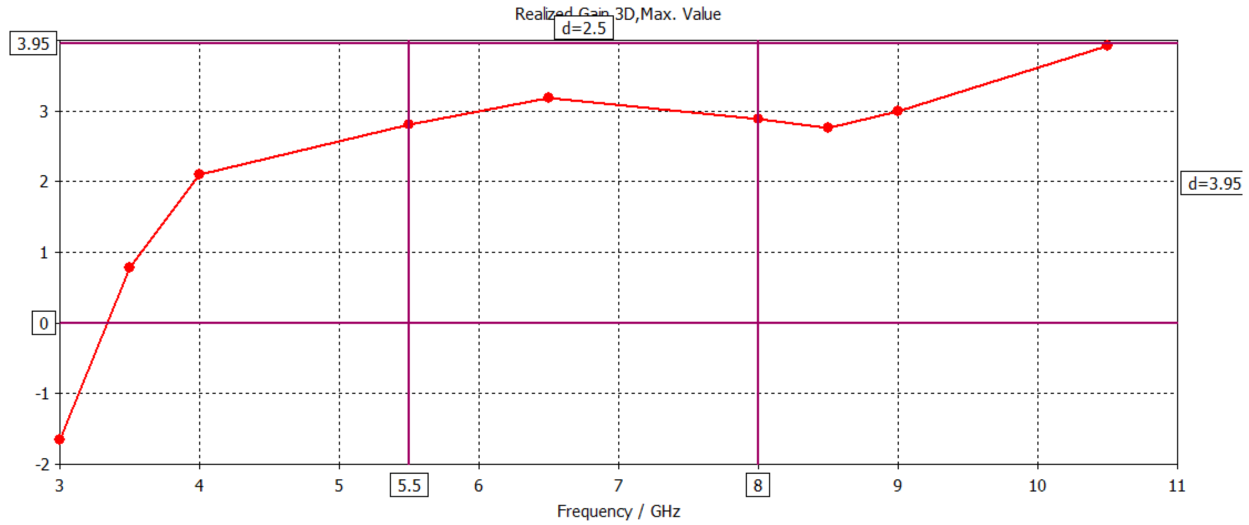
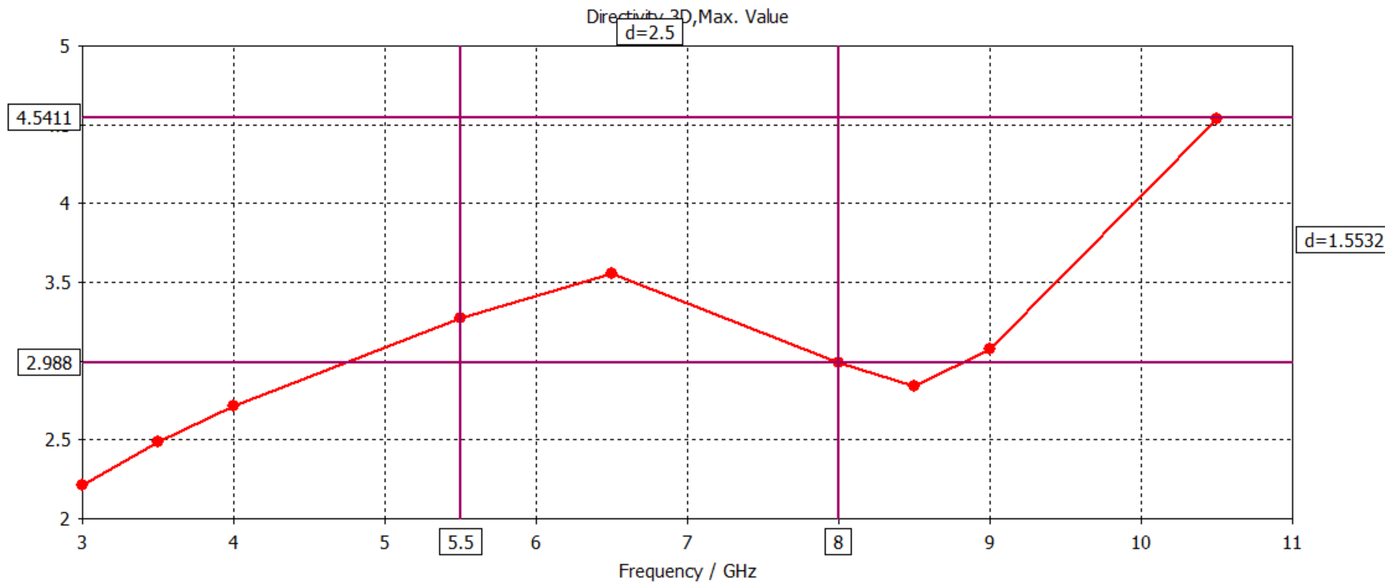


Fig 4.6 simulated 3d patterns

4.7 Gain plot



4.8 Directivity



4.9. Conclusions

1. In this case first resonant frequency decreases with increase in the diameter of the disc,

2. From this we can say that -10db returnloss is directly depend on the dimensions of the disc

3. Obtained gain is 3.95db,

4. Directivity is 4.5db

5. it is used for the space bourne applications and many more applications

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