DESIGN OF MICROSTRIP ANTENNAS FOR WIDEBAND APPLICATIONS

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Dissertation submitted for the partial fulfilment

of the requirements of the degree of

"BACHELOR OF TECHNOLOGY"

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CERTIFICATE

This is to certify that the thesis titled, "Design of microstrip patch antennas for Wideband applications" submitted by M. NARESH KUMAR and K RAVI KUMAR bearing the Roll No. 111EC0173 and 111EC0184 respectively is an authentic work carried out by them under my supervision and guidance for the partial fulfillment of requirements of degree of Bachelor of Technology in the department of Electronics and Communication Engineering.

Neither the thesis nor any part of this thesis has been submitted before for any kind of fulfilment of degree or any academic award elsewhere.

Signature of Supervisor

ACKNOWLEDGEMENT

This thesis has been benefited in various ways from several people. Whilst it would be simple to name them all, it would not be easy to thank them enough.

The enthusiastic guidance and active support of Prof. S.K.Behera has inspired us to stretch beyond our limits and to work hard. His motivating and inspiring insight has guided our thinking throughout our work and to improve the results in our work. Our sincere thanks to him.

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M Naresh Kumar (111EC0173)

K Ravi Kumar (111EC0184)

CONTENTS

ABSTRACT

Microstrip or patch antennas are getting to be progressively valuable on the grounds that they can be printed specifically onto a circuit board. They are broadly utilized as a part of flying machines, satellites, mobile, wireless application where size, weight, cost, ease of installation, aerodynamic profile are constraints, low profile like microstrip antennas may be needed. Hence design and development of cost effective and superior microstrip patch antenna has become an active research area. The size reduction and impedance bandwidth improvement lies in great importance in today's life. This thesis presents design of microstrip antennas for wireless applications. Four antennas designed are presented in the following chapters. The first design is a compact dual band microstrip antenna which produces dual band characteristics. The second design is a compact wideband microstrip antenna that has wideband characteristics. The third one is the Design of circularly polarized microstrip patch antenna using a pair of inserted slits. The fourth one is the design of hexagonal shaped patch antenna using coplanar waveguide feed. The antennas designed above have better radiation characteristics with improved bandwidth.

LIST OF DIAGRAMS

CHAPTER 1

MICROSTRIP PATCH ANTENNA

1.1 Introduction

The microstrip patch antenna consists of a radiating patch, substrate and ground plane. The patch stays as the upper layer. The ground plane lies on the bottom. In between radiating patch and ground plane there lies the patch. The patch is made of PEC material. The transmitting patch and the feed lines are typically photo etched on the dielectric substrate.

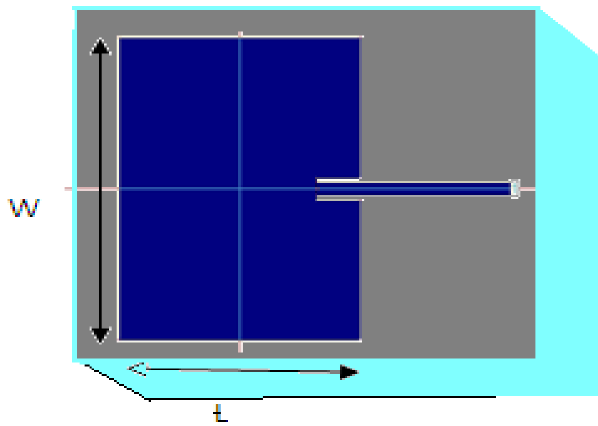


Fig 1.1: microstrip patch antenna structure

The patch is for the most part is square, rectangular, elliptical, triangular and circular. In case of rectangular patch, the length L of the patch is typically lies between 0.3333λo to 0.5 λo, where λo is the free-space wavelength. It has generally the thickness of t where t << λo. The thickness h of the substrate is generally $0.05\,\lambda o \geq h \geq 0.003\,\lambda o$.

The range of the dielectric constant of the substrate generally lies in between 2.2 to 12. For better radiation properties, a thick dielectric substrate having a low dielectric constant is attractive since this gives better efficiency and larger bandwidth. Henceforth, design must be analyzed for the antenna performance.

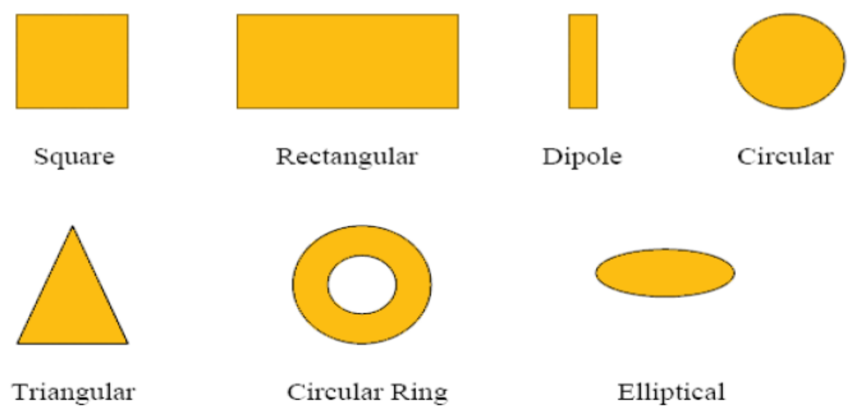


Fig 1.2: different types of microstrip patches

1.2 Advantages and Disadvantages

Microstrip antennas are expanding in prevalence for utilization in remote applications because of their position of safety structure. Subsequently, they are to a great degree perfect for embedded antennas in handheld remote gadgets, for example, cell phones, pagers and so forth. The telemetry and communication antennas on rockets need to be thin and conformal and are regularly as Microstrip patch antennas. Another territory where they have been utilized effectively is as a part of Satellite correspondence. Some of their vital favorable circumstances are given beneath:

- 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 capacity is low.
- Poor end fire radiator except tapered slot antennas
- Extraneous radiation from feeds and junctions
- Efficiency is low.
- Gain is low
- Narrow bandwidth
- Excitation of surface waves.

1.3 Design parameters

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

$$f_{\circ} = \frac{c}{2Le\sqrt{\epsilon_r}} \quad \text{---1.1}$$

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

$$L = Le - 2\Delta L \quad \text{-----------------------------1.2}$$

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\epsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad \text{-----------------------------1.3}$$

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}(1+\frac{12h}{W})^{\frac{-1}{2}} \quad \text{------------------------- 1.4}$$

1.5. Feed Techniques

The feeding techniques used for microstrip patch antennas are:

1.5.1: Microstrip Line Feeding

In this kind of feed technique, a conducting strip is joined to the edge of the Microstrip patch as shown in Figure 1.3. The feed line impedance is matched with that of patch.

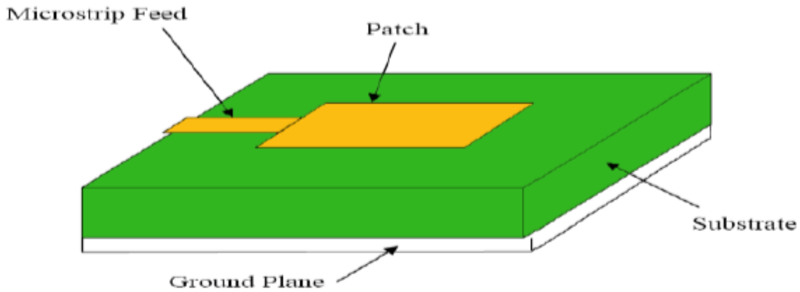


Fig 1.3: Microstrip Feed Line

This is done by controlling the inset feed position. It is easy to model and fabricate by varying the position of the feed. But, if the substrate thickness increases then surface waves increases that results in narrow bandwidth.

1.5.2 Coaxial Feed

The Coaxial feed or probe feed is an extremely basic procedure utilized for sustaining Microstrip patch antennas. The internal transmitter of the coaxial cable conductor penetrates through the dielectric and is welded to the transmitting patch, while the external conduit is associated with the ground plane.

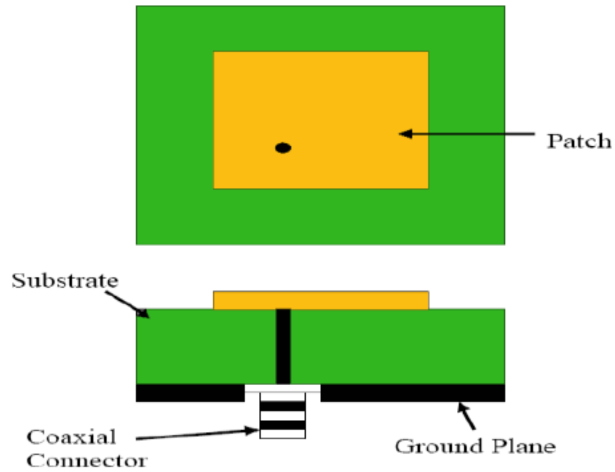


Fig 1.4: coaxial feeding

This feed procedure is definitely not hard to make and has low spurious radiation. Regardless, a noteworthy disservice is that it gives jolt information exchange limit and is difficult to model following an opening must be exhausted in the substrate and the connector extends outside the ground plane, thusly not making it absolutely planar for thick substrates (h >0.02λo). Moreover, for thicker substrates, the extended test length makes the data impedance more inductive, inciting arranging issues. It is seen over that for a thick dielectric substrate which gives wide transfer speed, the microstrip line feed and the coaxial feed experience the ill effects of various hindrances. The non-reaching feed strategies which have been talked about underneath, illuminate these issues.

1.5.3 Aperture Coupled Feed

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

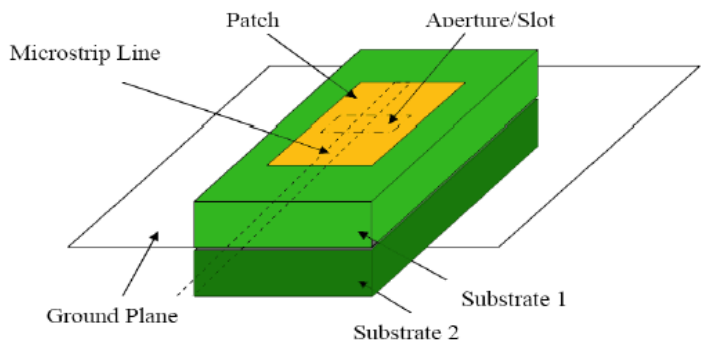


Fig 1.5 Aperture coupled feed

The upper substrate is made of lower permittivity than the lower substrate so that it can produce loosely bound fields with better radiation. The lower substrate is made of higher value of permittivity that will not emit spurious radiation.

1.5.4 Proximity coupling

This sort of feeding system is likewise referred to as the non-magnetic coupling feeding technique. It essentially utilizes two substrates and the transmitting patch is on top of the upper substrate. The feed line is set under the upper substrate and the ground plane is put under the lower substrate. In this sort of procedure there is no spurious food radiation and transmission limit is high. This kind of network is mainly capacitive.

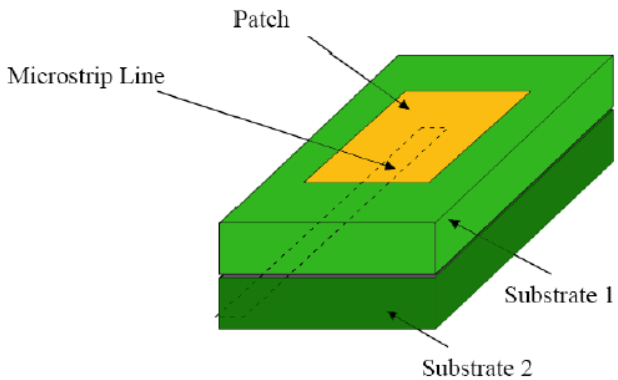


Fig1.6: Proximity Feed Technique

1.5.5 Coplanar waveguide feed

Coplanar waveguide feed is the favored transmission line for MMICs .Both the microstrip antennas and the CPW are in the planar geometry. With MMICs for integrating microstrip antennas, it is preferable to feed microstrip antennas with a CPW.in the ground plane of microstrip antenna CPW is etched. Via a slot coupling is etched. The difference between aperture coupling and coplanar wave guide is that in the aperture coupled microstrip antennas the slot in the ground plane is feed by a microstrip line. CPW feed advantage is that the coplanar waveguide is being excited in the odd mode of the coupled slot line, the radiation is negligible from the feed structure.

1.6 Methods of Analysis

There are several methods for analyzing the microstrip patch antennas are transmission line model, cavity model and full wave model. The transmission model is less complex and is comprehensible but it is less precise. Whereas in cavity is more complex as compared to transmission model and it is more precise gives great physical knowledge. The full wave model are exact, adaptable and can treat single components, limited and limitless clusters, subjectly molded components and coupling. These models give less understanding as compared to previous models.

1.6.1 Transmission Line Model

The microstrip antenna is represented as array of two radiating apertures, each of of width W and substrate height separated by length L.

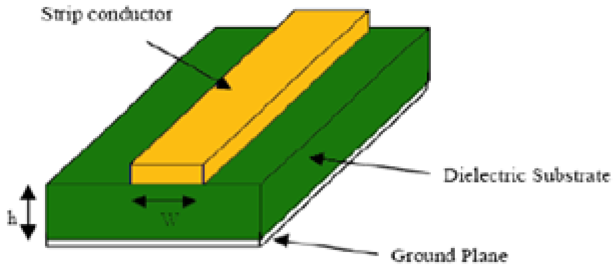


Fig 1.7: Microstrip feed line

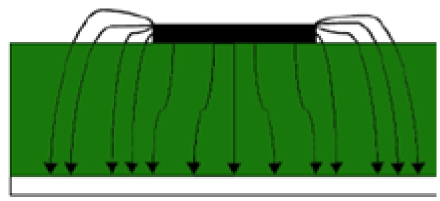


Fig 1.8: Electric field lines

Most of the electric field lines infiltrate in the substrate and parts of a couple of lines perceptible all around. Thusly, this transmission line can't reinforce the flawless TEM system for transmission since the stage velocities would be particular observable all around and the substrate. Maybe, the staggering system for multiplication would be the semi TEM mode.

The effective dielectric constant is a function of frequency. The calculation of ϵ_{reff} is lower than the ϵ_r due to fact that the bordering fields around the fringe are not bound to the substrate rather likewise noticeable.

The formula for ϵ_{reff} according to [1] is given as:

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{\frac{-1}{2}} \qquad \text{--------- } 1.5$$

Where
ϵ_{reff} = effective dielectric constant
ϵ_r = dielectric constant of the substrate
h = height of the dielectric substrate
W = width of the patch

In the fig 1.8 the microstrip patch having length L, width W laying on a substrate h.In direction chosen below length is along x-axis, width is along y-axis and height is along z-axis.

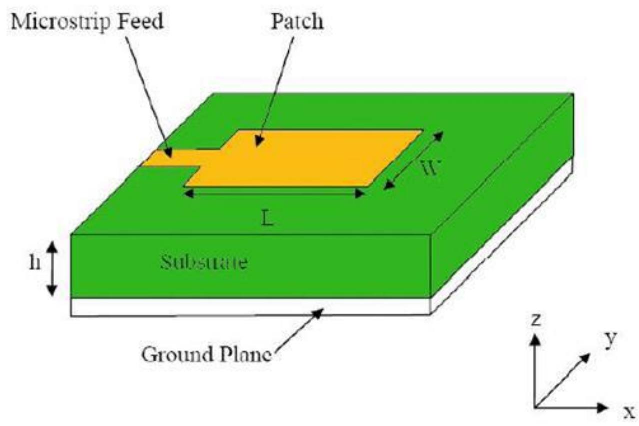


Fig 1.9: Microstrip patch antenna

To work in the focal TM10 mode, the length of the patch must be inconsequential not unequivocally λ/2 where λ is the wavelength in the dielectric medium and is practically identical to $\frac{\lambda_o}{\sqrt{\epsilon_{reff}}}$ where λo is the free space wavelength. The TM10 mode suggests that the field moves one λ/2 cycle along the length, and there is no blended sack along the width of the patch. In the Fig 1.10 exhibited underneath, the microstrip patch antenna is tended to by two spaces, segregated by a transmission line of length L and open circuited at both the terminations. Along the width of the patch, the voltage is most critical and current is scarcest by virtue of the open consummations. The fields at the edges can be dead set into run of the mill and tangential divides with respect to the ground plane.

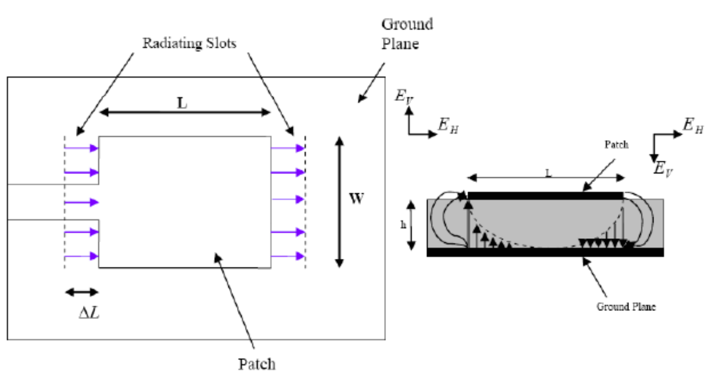


Fig1.10 Top view and side view of microstrip patch antenna

It is seen from Fig 1.10 that the standard parts of the electric field at the two edges along the width are in reverse course and in this way out of stage taking after the patch is λ/2 long and hence they scratch off each other in the broadside bearing. The tangential parts (seen in Fig 1.10, which are in stage, infers that the consequent fields join to give most magnificent astounding field typical to the surface of the structure. Along these lines, the edges along the width can be identified with as two radiating spaces, which are λ/2 differentiated and occupied with stage and transmitting in the half-space over the ground plane. The bordering fields along the width can be shown as transmitting openings and electrically the patch of the microstrip radio antenna looks a bigger number of noticeable than its physical estimations. The estimations of the patch along its length have now been joined on every end by a separation ΔL, which is given as in equation 1.3

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

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

the effective length Leff for a given Resonance frequency fr is

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

the resonance frequency for any TMmn ,For a rectangular microstrip patch antenna for efficient radiation, the width W is given as

$$W = \frac{1}{2f_r\sqrt{\mu_\circ\epsilon_\circ}}\sqrt{\frac{2}{\epsilon_{reff}+1}} = \frac{c}{2f_r}\sqrt{\frac{2}{\epsilon_{reff}+1}}$$ --1.6

Where the free space speed of light is c.

1.6.2 Cavity Model:

In this sort of model, the range between the patch and the ground plane is managed as a cavity that is enveloped by magnetic dividers around the outskirts and by electric dividers from the top and base sides. Since thin substrates are used, the field inside the cavity is uniform along the thickness of the substrate. The fields underneath the patch for standard shapes, for example, rectangular, round, triangular, and sectoral shapes can be communicated as a summation of the distinctive resonating modes of the two-dimensional resonator. The bordering fields around the outskirts are managed by expanding as far as possible outward so that the convincing estimations are greater than the physical estimations of the patch. The effect of the radiation from the antenna and the conductor loss are spoken to by adding these losses to the loss tangent of the dielectric substrate. The far field and radiated power are figured from the indistinguishable magnetic current around the periphery. A substitute technique for joining the radiation affect in this model is by showing an impedance utmost condition at the dividers of the cavity. The bordering fields and the radiating power are banished inside the cavity yet are limited at the edges of the cavity. Nonetheless, the answer for the far field, with permission of admittance dividers is difficult to survey.

The resonant frequencies in the cavity are:

$$(f_r)_{mnp} = \frac{1}{2\pi\sqrt{\mu\epsilon}}\sqrt{(\frac{m\pi}{h})^2 + \left(\frac{n\pi}{L}\right)^2 + (\frac{p\pi}{W})^2} \quad \text{--1.7}$$

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

Considering TM_{010},

$$(f_r)_{010} = \frac{1}{2L\sqrt{\mu\epsilon}} = \frac{v_\circ}{2L\sqrt{\mu\epsilon}} \quad \text{-----------------------1.8}$$

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

CHAPTER 2

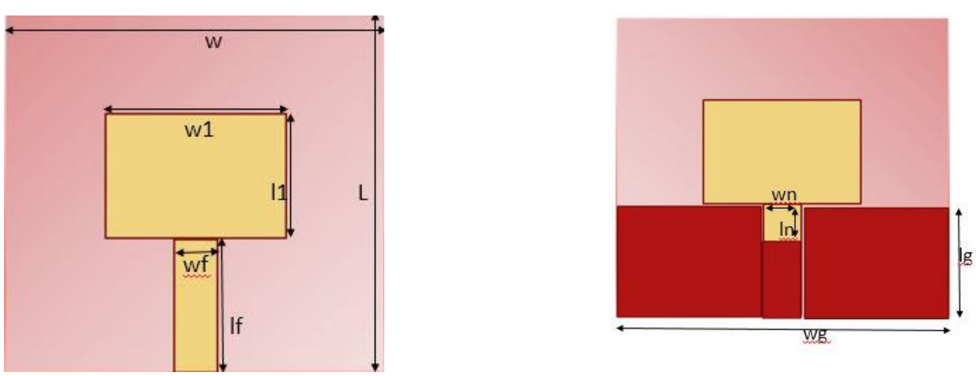
COMPACT DUAL BAND MICROSTRIP ANTENNA

2.1- Introduction

In this chapter we designed a compact dual band microstrip antenna. The proposed antenna is working under two different resonating frequencies that are far apart. The division of these two frequencies gives the dual band characteristics. There is no need of designing two antennas that work at two different frequencies. We obtained those characteristics in single antenna. A new antenna is designed with improved impedance bandwidth. The antenna is analyzed with simulated characteristics like return loss, radiation pattern, surface currents distribution, VSWR, gain and directivity.

2.2- Antenna Geometry

The geometry of the design is shown in the figure Fig 2.1. The Radiating patch is of PEC material. The dielectric constant of substrate is of ϵ_r=4.4 and thickness is 1.6mm.The ground plane is of material PEC which is notched in this case. The dimension of the substrate is 30×34 mm^2 (W×L). The dimension of the ground plane is 30×13.5 mm^2 (W×L) and the dimensions of the notch inside the ground plane is 4×3.5 mm^2 (W×L). The dimensions of the patch is 16×16 mm^2 (W×L).Partial ground plane with a notch is used to improve the impedance bandwidth. The radiating patch if fed by using microstrip feedline technique .The dimensions of the microstrip feedline is 2.9×14.5 mm^2 (W×L).



(a) (b)

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

Antenna design parameters:

Substrate:

W=30mm, L=34mm, h=1.6mm

Patch:

W1=16mm, l1=16mm,d=0.5mm

Feedline:

Wf=2.9mm, lf= 14.5mm

Ground plane:

Wg=30mm, lg=13.5mm,d=0.05mm

2.3- Results

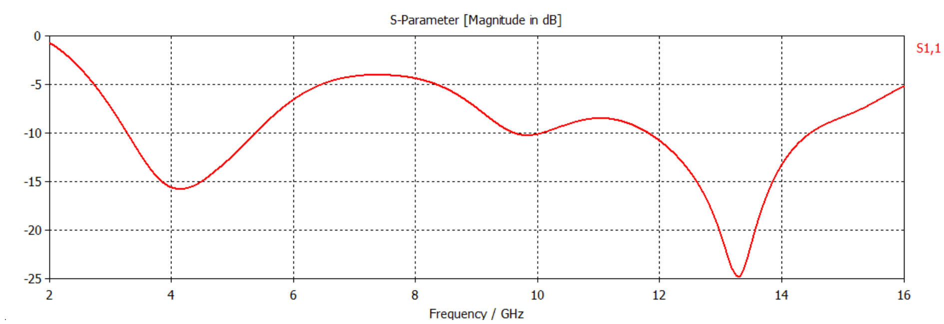


Fig 2.2: Reflection coefficient of compact dual band microstrip antenna

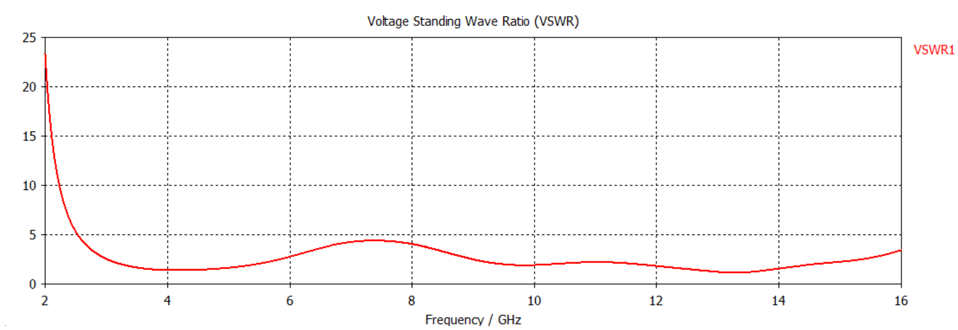
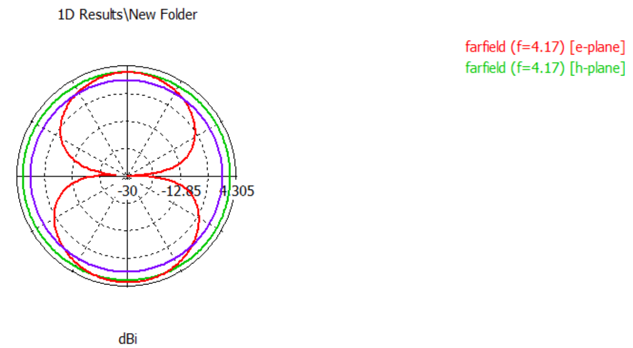


Fig 2.3:VSWR plot of compact dual band microstrip antenna



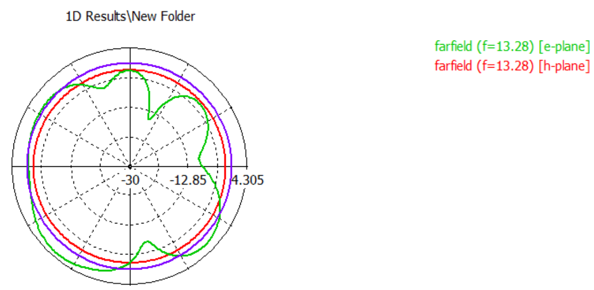


Fig 2.4: Radiation pattern of compact dual band microstrip antenna

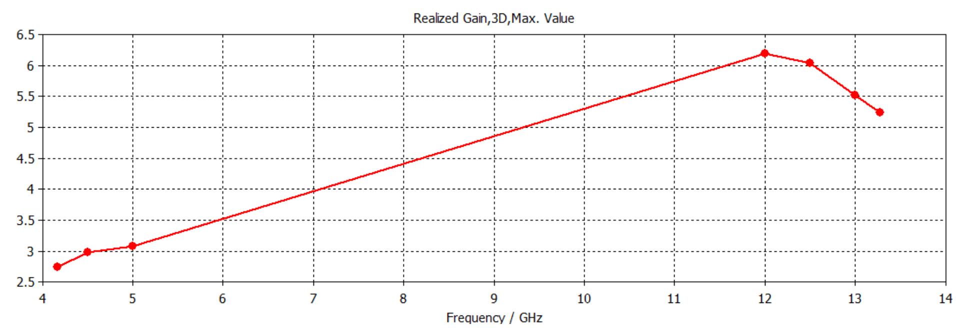


Fig 2.5: Realised Gain of compact dual band microstrip antenna

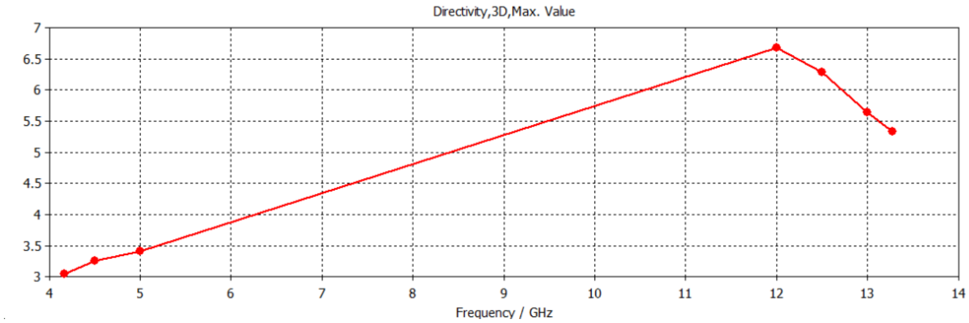
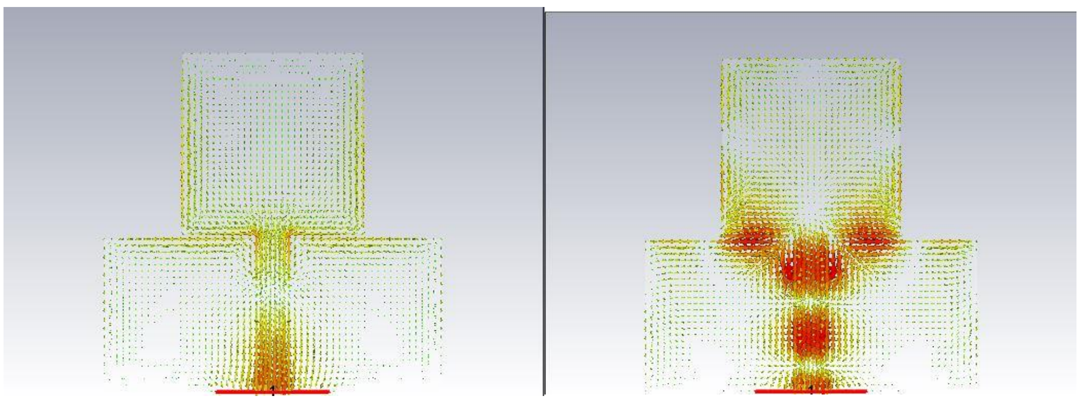


Fig 2.6: Directivity of compact dual band microstrip antenna



(a) (b)

Fig:2.7 Surface Current distribution of compact dual band microstrip antenna at (a)f=4.17 GHz & (b)f=13.28 GHz

2.4- Conclusions

In this design,a compact dual band microstrip patch antenna was proposed.The microstrip patch was excited by microstip feedline technique.The designed antenna covers the bandwidth from 3.2845 to 5.4206 GHz and 11.814 to 14.473 GHz. Resonating frequencies are obtained at 4.1505 GHz and 13.287GHz,The return loss at reonating frequencies are 15.8 db and 24.9 db.The gain is maximum at 12 GHz i.e 6.2db.The proposed antenna has some wideband applications like precision radar-imaging technology, precision locating and tracking, RADAR, remote sensing.

CHAPTER 3

COMPACT WIDEBAND MICROSTRIP ANTENNA

3.1- Introduction

In this chapter,a compact wideband microstrip antenna is designed. At the point when an antenna must work at two frequencies that are far apart,a dual-frequency antenna can be utilized to evade the utilization of two different antennas. At the point when two or more resonating frequencies of a MSA are near to one another, a wide BW is acquired. At the point when these are differentiated, double band operation is gotten. All in all, all the routines depicted before for expanding the BW of MSAs can be used to get dual band characteristics. In different arrangements, either electromagnetic or gap coupling could be utilized for dual-band operation. The division between the two frequencies is gotten by changing the measurements of the patch.The antenna is analyzed with simulated characteristics like return loss, radiation pattern, surface currents distribution, VSWR, gain and directivity.

3.2- Antenna Geometry

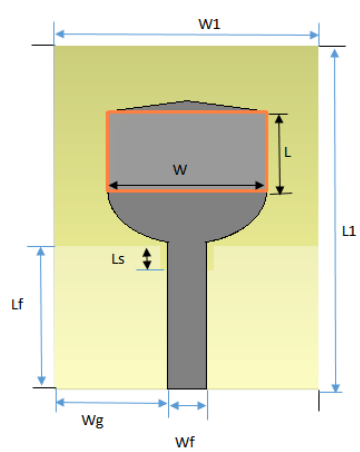


Fig 3.1: proposed antenna geometry

In this design the radiating patch is made of 3 different parts. The upper piece of patch is triangle,the center part is rectangular and lower part is semi-cirle.The geometry of the design is shown in the figure Fig3.1. The Radiating patch is of PEC material of thickness t=0.05mm. The dieclectric constant of substrate is of ϵ_r=4.4 and thickness is 1.6mm.The ground plane is of material PEC which is also notched in this case.

The dimension of the substrate is 20× 26 mm^2 (W×L). The dimension of the ground plane is 20×10.8 mm^2 (W×L) and the dimensions of the notch inside the ground plane is 4×1.8 mm^2 (W×L). The dimensions of the patch is 12×6 mm^2 (W×L).Partial ground plane with a notch is used to improve the impedance bandwidth. The radiating patch if fed by using microstrip feedline technique .The dimensions of the microstrip feedline is 3×11.1 mm^2 (W×L).

3.3- Results

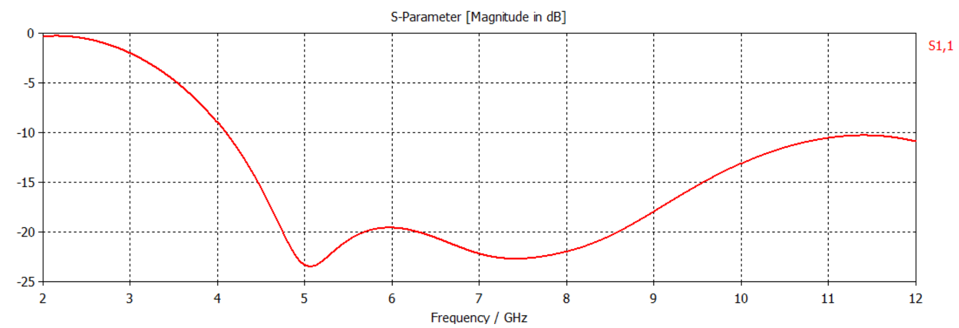


Fig 3.2 : Reflection coefficient of compact Wideband microstrip antenna

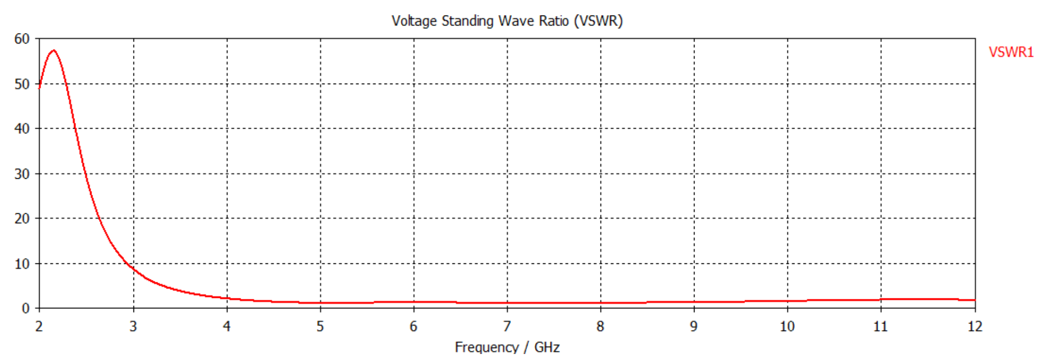


Fig 3.3:VSWR plot of compact Wideband microstrip antenna

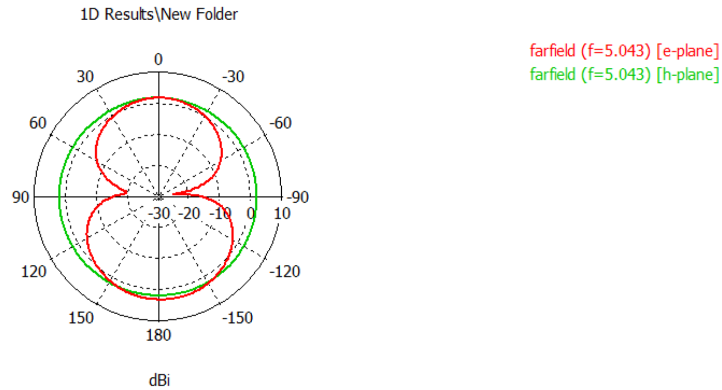


Fig 3.4:Radiation pattern of compact Wideband microstrip antenna

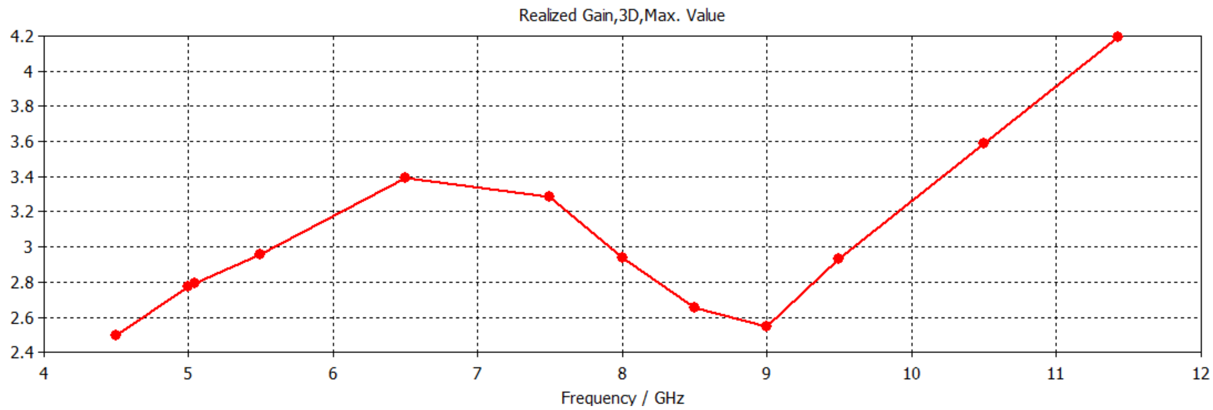


Fig 3.5:Realised gain of compact Wideband microstrip antenna

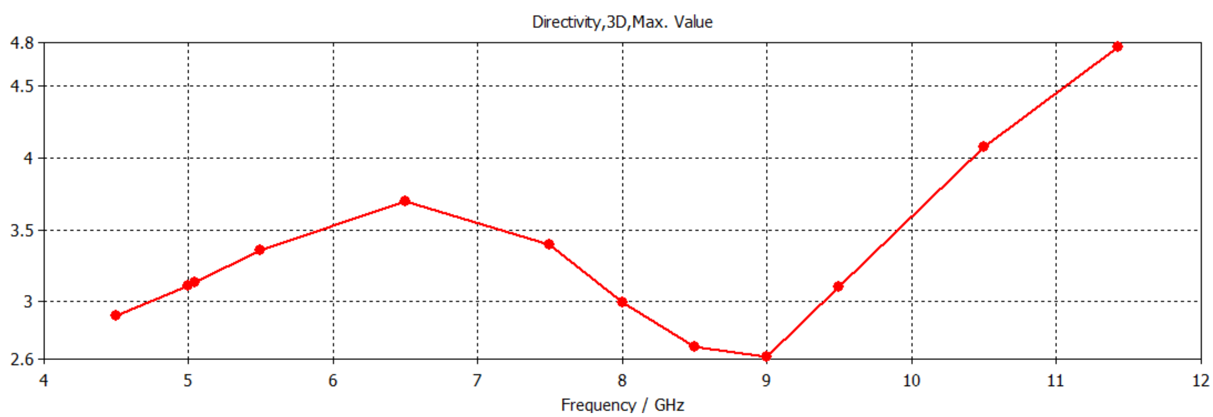


Fig 3.6 : Directivity of compact Wideband microstrip antenna

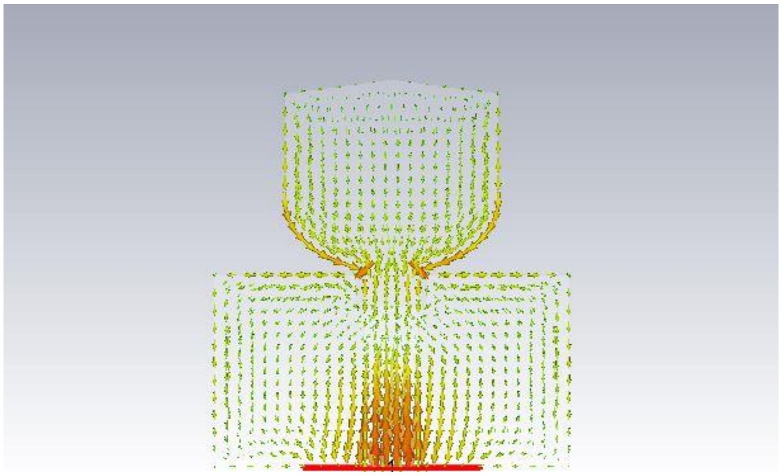


Fig 3.7:Surface current distribution of compact Wideband microstrip antenna

3.4- Conclusion

In this design,a compact wideband microstrip patch antenna was proposed.The microstrip patch was excited by microstip feedline technique.The designed antenna covers the bandwidth from 4.124 to 12 GHz. Resonating frequencies is obtained at 5.043 GHz,The return loss at reonating frequency is 2.5 db.The gain is maximum at 11.44 GHz i.e 4.2db.The directivity is maximum at 11.4 GHz i.e. 4.8dBi.The proposed antenna has some wideband applications like precision radar-imaging technology, precision locating and tracking, RADAR, remote sensing. In medical field,there are applications like human body monitoring and imaging applications in intensive care units,home health care,pediatric clinics,rescue operations like heart beting under emergency situations.

CHAPTER 4

CIRCULARLY POLARISED MICROSTRIP PATCH ANTENNA USING A PAIR OF INSERTED SLITS

4.1-Introduction

When two orthogonal modes are excited with a 90◦ time-phase difference between them circular polarization is obtained. This can be accomplished by adjusting the physical dimensions of the patch and using either single, or two, or more feeds. For a square patch element, the easiest way to excite ideally circular polarization is to feed the element at two adjacent edges, to excite the two orthogonal modes; the TM*x* 010 with the feed at one edge and the TM*x* 001 with the feed at the other edge. The quadrature phase difference is obtained by feeding the element with a 90◦ power divider or 90◦ hybrid.In some other designs compact circular polarization(CP) can be obtained by truncating patch corners or tips, inserting a Y-shaped slot ,introducing small peripheral cuts at the boundary of a circular patch, adding a tuning stub or a bent tuning stub.In this chapter,we proposed a compact circularly polarised microstrip patch antenna using a pair of inserted slits. The antenna is simulated and analyzed by varying the lengths of slits and various characteristics like return loss,radiation pattern are observed.

4.2-Antenna Geometry

The geometry of the design is shown in the figure Fig 4.1. The Radiating patch is of PEC material of thickness t=0.05mm. The dieclectric constant of substrate is of ϵ_r=4.4 and thickness is 1.6mm.The ground plane is of material PEC.The dimension of the substrate is 60× 60 mm^2 (W×L). The dimension of the ground plane is 60×60 mm^2 (W×L). The dimensions of the patch is 30×30 mm^2 (W×L).The antenna is excited by dual feed using coaxial/probe feeding technique. Two feeds are used at C(for RHCP) and D(for LHCP). Feed positions are measured by ratio AC/AB which is 0.32 i.e constant for all cases. The slit lengths lx and ly are varied.

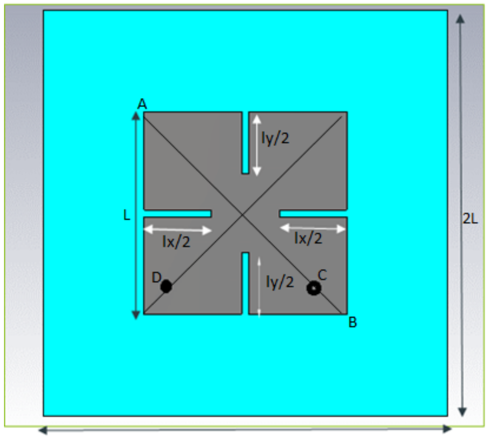


Fig 4.1:CP MSA using a pair of inserted slits

Slit lengths(mm) Lx,ly	Slit ratio	Feed position d=AC/AB	Resonating frequency
0,0	___________	0.36	3.3958
10,6.4	1.563	0.36	3.1146
15,13.1	1.145	0.36	2.6721
20,18.2	1.087	0.36	2.2629

Fig 4.2:Table of various slit lengths lx and ly

4.3- Results

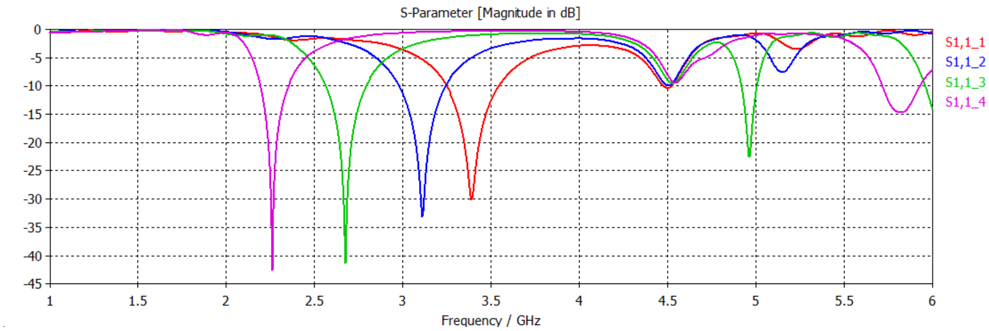


Fig 4.3: Reflection coefficient at various slit lengths

S1,1_1(lx=0,ly=0); s1,1_2(lx=10,ly=6.4); s1,1_3(lx=15,ly=13.1); s1,1_4(lx=20,ly=18.2)

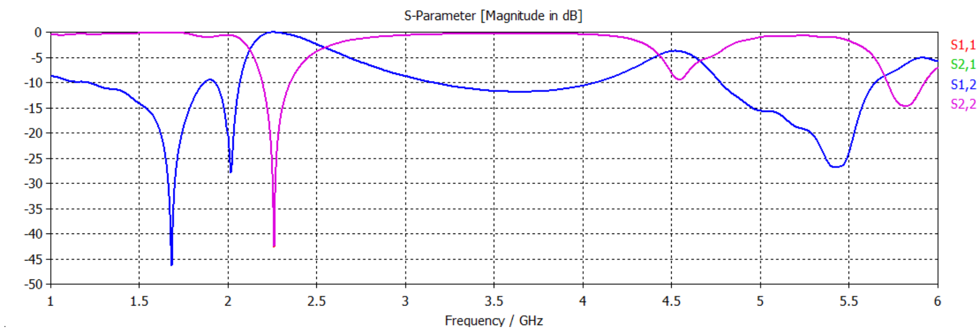
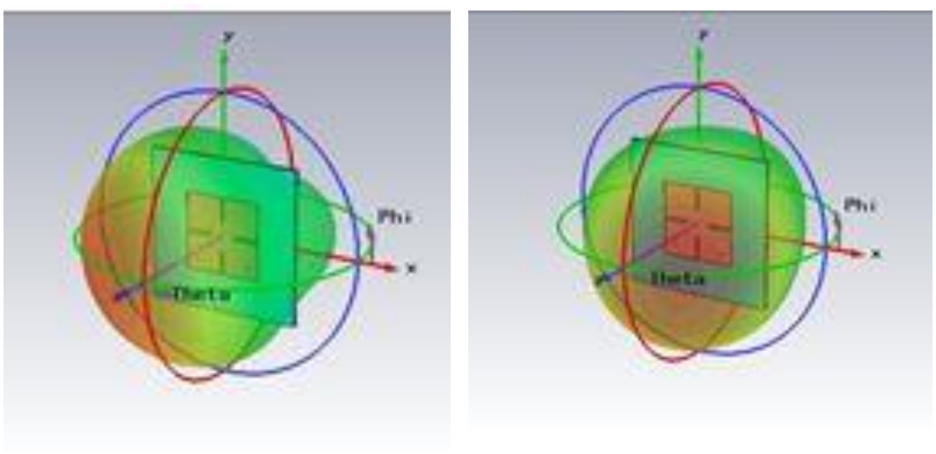
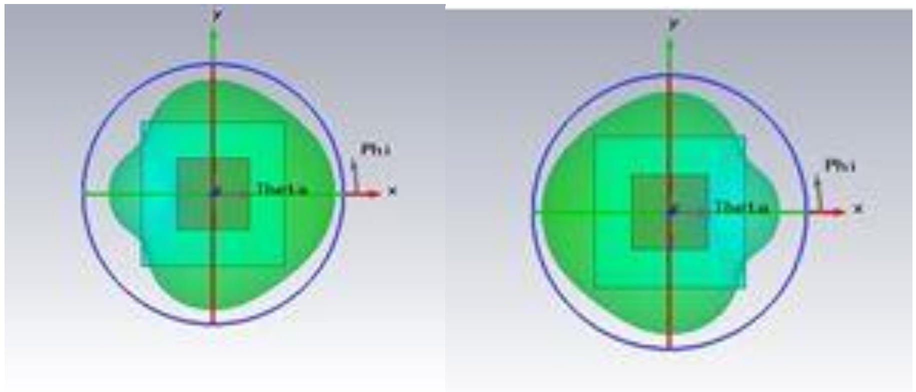


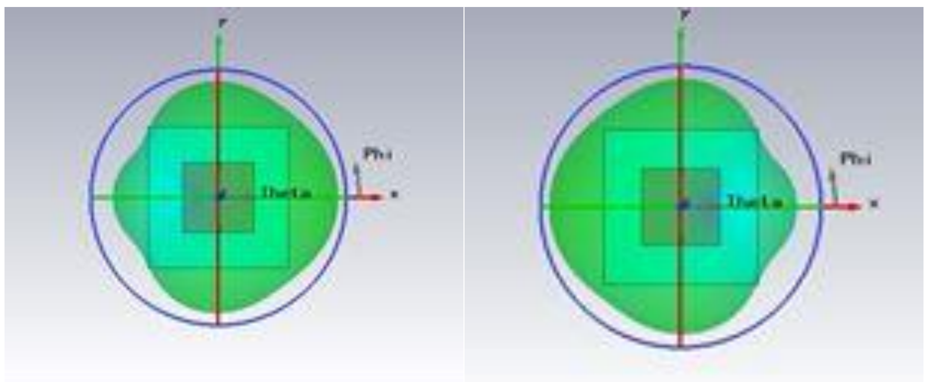
Fig 4.4: Reflection coefficeint at final optimized value of lx=20, ly=18.2



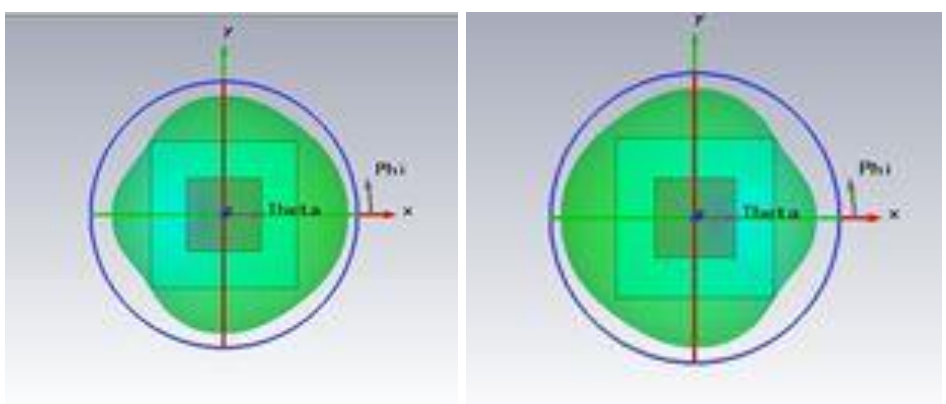
(a)



(b)



(c)



(d)

Fig 4.5: Radiation pattern at different frequencies for different slit lengths.
(a)lx=20, ly=18.2 (b)lx=15, ly=13.1, (c)lx=10,ly=6.4, (d)lx=0,ly=0

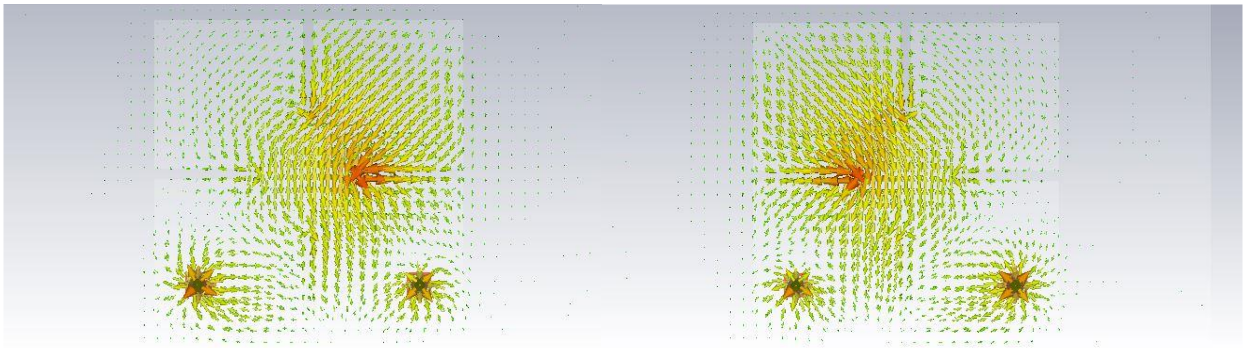


Fig 4.6: surface current distribution at final optimized slit length at f=2.2629 GHz

4.4- Conclusion

In this design,a minimal circularly microstrip patch reception apparatus was proposed.The microstrip patch was energized by coaxial feedline strategy. The resonating frequency diminishes with expanding slit length. For the instance of lx = 20 mm and ly = 18.2 mm, the CP freuency reduces to around 2.2629 MHz [about 0.66 times that (3.3958 MHz) of the case without slits. This relates to a patch size diminishment when contrasted with the case utilizing single-feed CP design without slits.The resonating frequency is acquired at 2.2629 for lx=20,ly=18.2 and return loss at that frequency is 42.5 dB. The radiation pattern is gotten for distinctive slit lengths.

CHAPTER-5

HEXAGONAL SHAPED PATCH ANTENNA USING CPW FEED

5.1- Introduction

In this chapter,a hexagonal shaped patch antenna is designed using coplanar waveguide feed.The antenna is designed using FR-4 substrate and thickness 1.6mm.The simulated results such as return loss, VSWR,radiation pattern, surface currrents, realised gain and directivity are observed by varying one of the parameters(w1).

5.2- Antenna Geometry

The geometry of the design is shown in the figure Fig 5.1. The Radiating patch is of PEC material of thickness t=0.05mm. The substrate used is FR-4 and thickness is 1.6mm.The dimensions of substrate is 25.5× 25 mm^2 (W×L).

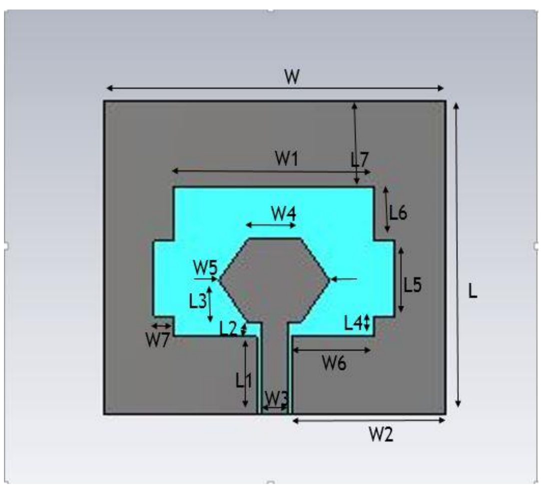


Fig 5.1: hexagonal shaped patch antenna using coplanar waveguide feed

Length	Size(mm)	Width	Size(mm)
L1	6.17	W1	15,16,17
L2	1.15	W2	8.4
L3	3.3	W3	2.6
L4	1.615	W4	4
L5	6	W5	8.3
L6	4.39	W6	5.9
L7	6.93	W7	1.5
L8	4.25		

5.3- Results

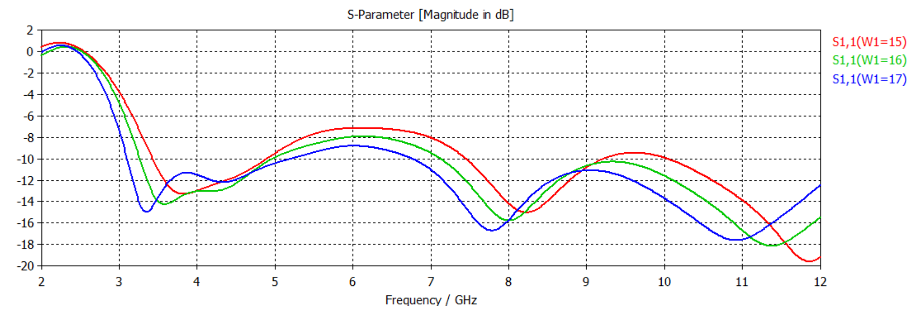


Fig 5.2: Reflection coefficients hexagonal shaped patch antenna at vaious lengths w1=15, w1=16 and w1 =17mm.

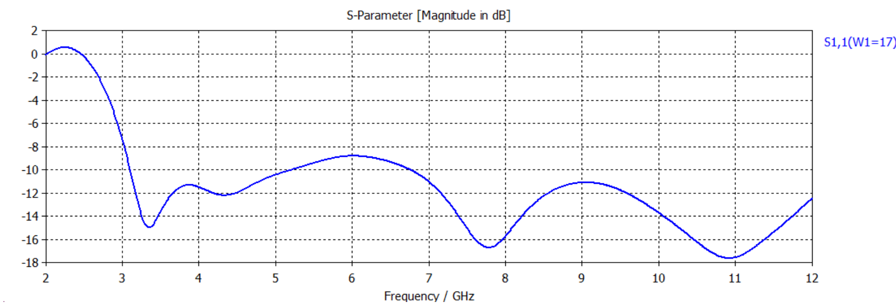


Fig 5.3 : Reflection coefficients hexagonal shaped patch antenna at w1=17mm.

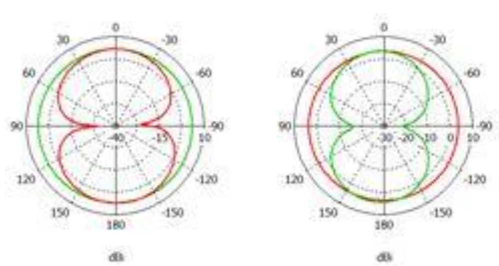


Fig 5.4: Radiation Pattern of hexagonal shaped patch antenna at f=3.37 and f=7.73GHz

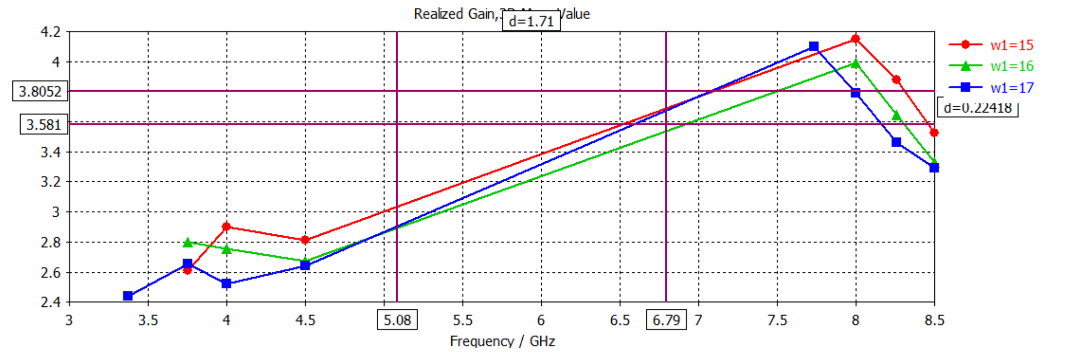


Fig 5.5: Realised Gain of hexagonal shaped patch antenna at w1=15,w1=16 and w1=17mm.

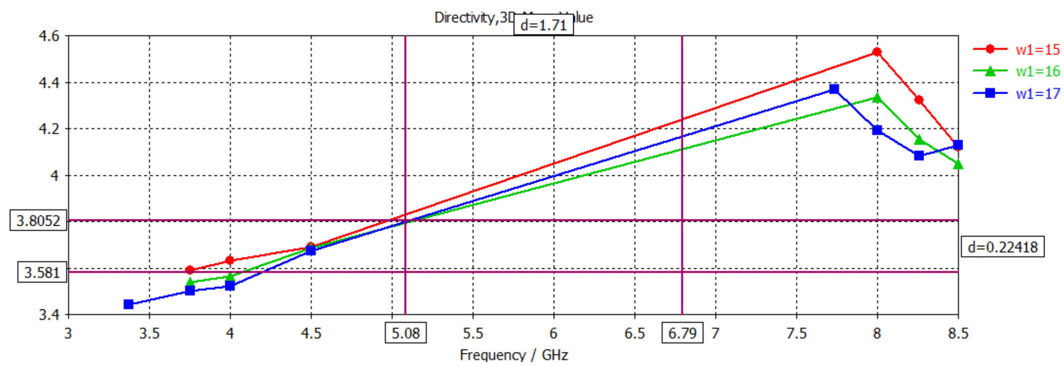
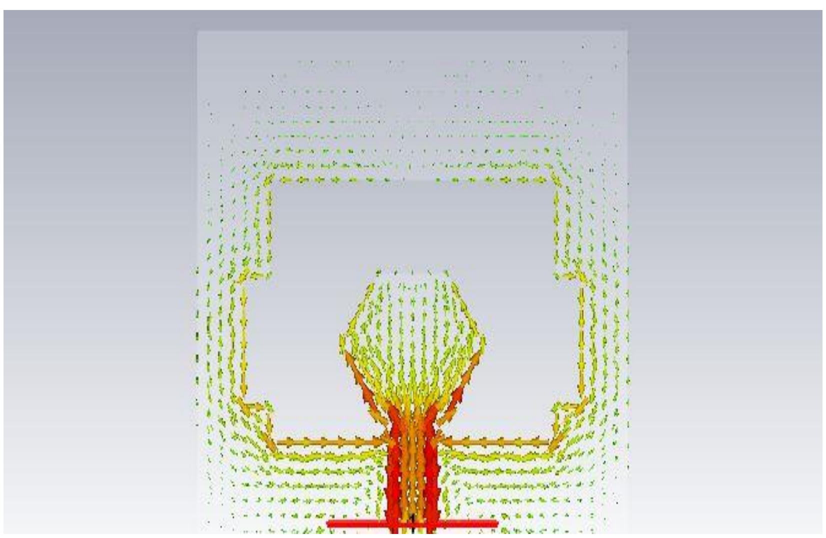
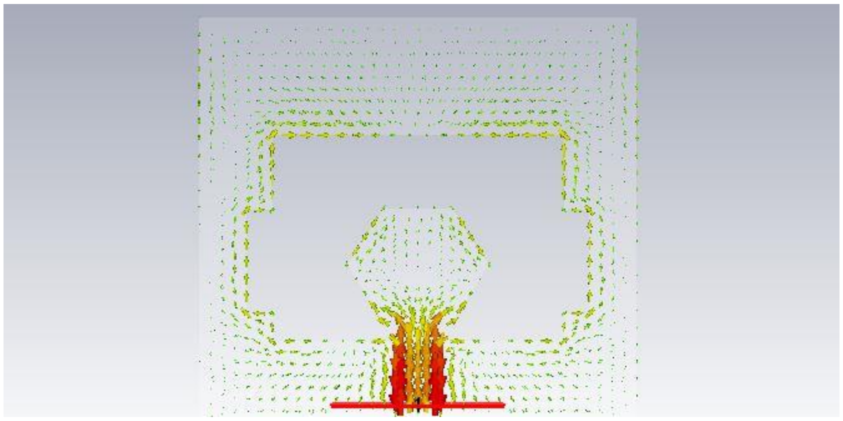


Fig 5.6: Directivityof hexagonal shaped patch antenna at w1=15,w1=16 and w1=17mm.



(a)



(b)

Fig 5.7: Surface Current distribution of hexagonal shaped patch antenna at (a) f=3.37GHz (b) f=7.73GHz

5.4- Conclusion

In this design,a hexagonal shaped microstrip patch antenna using coplanar waveguide was proposed.The microstrip patch was excited by coplanar waveguide technique.The designed antenna covers the bandwidth from 3.03 to 5.2 GHz and 6.7 to 12 GHz. Resonating frequencies is obtained at 3.37 GHz and 7.73 GHz. The return loss at reonating frequency is -15 dB and -16.4dB respectively.The gain is maximum at 7.73GHz i.e 4.1db.The directivity is maximum at 7.73 GHz i.e. 4.39 dBi.The proposed antenna has dualband characteristics.

CONCLUSION

Microstrip antennas (MSAs) have a few preferences over routine microwave reception antennas, for example, their light weight, little volume, and planar configuration. Different strategies for analyzing MSAs are briefly portrayed. These antennas are utilized as a part of UHF to millimeter-wave frequency groups. The fundamental restriction in the ever increasing uses of these antennas is their narrow BW. Fortunately, the BW can be expanded by utilizing a thick substrate with a low dielectric constant.

Other methods for increasing the BW of MSAs include directly coupled multi resonators, planar gap coupled, stacked electromagnetically coupled or aperture-coupled patches, impedance-matching techniques, log-periodic configurations, and ferrite substrates.

FUTURE WORK

Based on antenna designs, the following points were identified which would be helpful for further investigation.

- Fabrication and measurements of compact wideband microstrip antenna and hexagonal shaped patch antenna will be carried out in future.
- Circularly polarized antennas can further be designed using other techniques like power divider and 90° hybrid.

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