Miniaturized circular shaped patch antenna for C/X band applications

Mamta Rao Kalwa[1] Naresh Kasnia[2]
[1]Student [2]Assistant Professor
[2]ECE Department
[1,2]JCDM College of engineering, Sirsa, Haryana, India.

Abstract— In this paper circular shaped stack patch antenna has been proposed. In this slots have been cut on the patch for size miniaturization.FR-4 epoxy has been used as a substrate. The proposed antenna resonates at 6.28 GHz, 7.3 GHz, 8.54 GHz and10.18Ghz VSWR≤2 in 5.9-10.7 GHz frequency band. This wideband antenna works for multiband applications. In this paper return loss, bandwidth, radiation patterns, VSWR, gain have been studied. Ansoft HFSS tool has been used for designing and simulation. Efficiency of proposed antenna is 86%.It works for Wimax, satellite (6.2-7.2 GHz), Wireless applications (WLAN) and radar applications, medical applications

Key words**:** Airborne radar, satellite, wireless.

I. INTRODUCTION

An antenna is an electric device which converts electric power in to radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver Micro strip antennas are probably the most utilized micro strip patches in today's global market [1]. Micro strip antennas pose some attractive features for modern communication system, such as low profile, light weight, ease of manufacturing and conformability [2]. Antenna miniaturization is an important task in achieving an optimal design for wireless applications. In the present scenario there is a fall in the size of electronics system and a miraculous increase in the functionality. The operating frequency of the antenna, also considered as the distinguished characteristics seem to have an influence on the radiation characteristics. The antenna with multiband operation and smaller dimensions are the requirement of modern telecommunication systems But available researches show that with the reduction of antenna size there is a change in the bandwidth, gain and efficiency of antenna. The immense progress of wireless industry has also sparked at interest in multiband antennas [3]. Further it is analyzed that after a few iteration gain, bandwidth and other factors begin to decrease.

A micro strip antenna consists of a metallic pattern on one side of a dielectric substrate and ground plane on the other side of the substrate. Micro strip antenna has disadvantages like low return loss, less bandwidth and low gain. So as to improve characteristics, Size miniaturizations have been applied.

II. ANTENNA GEOMETRY

The structure of proposed, modified, Circular-shaped antenna is illustrated in Figure.1 below.

The basic antenna structure begins as a circular-shaped patch. The radiating patch is created by cutting six rectangular shaped slots of similar width 0.52mm and arm lengths of its narrow rectangular slots lines are 9mm, 7mm, 5mm for middle slot, side slot, outer slot. The diameter of circular radiator is chosen as 19.42mm. The radiating element and feeding line are printed on the same side of the micro strip patch, which has a thickness of 1.975mm and FR-4 Epoxy substrate has been taken having thickness of 1.5mm , dielectric constant of εr=4.4 and tan δ = 0.02,

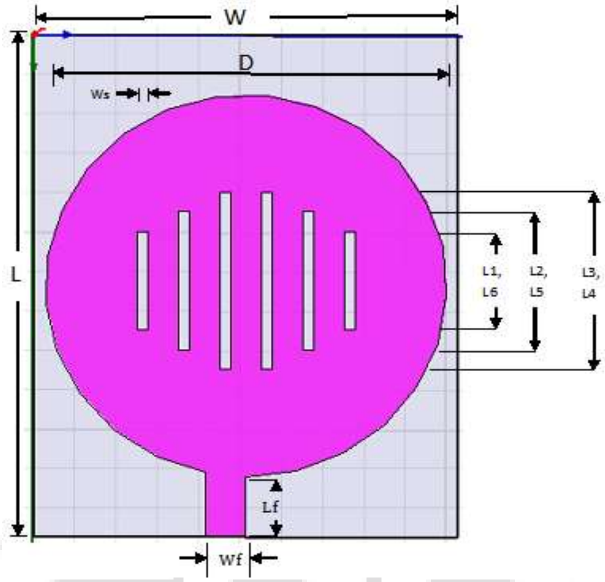


Fig. 1: Proposed circular antenna

while the other side is the full ground plane of the antenna. The micro strip transmission line, for which the signal-strip thickness and length are denoted by Wf and Lf, respectively, is used to feed the antenna.

The optimal geometrical parameters of the proposed antenna are as follows: L = 25.5mm,   = 20.5mm, $L1$ =$L6$ = 5 mm, $L2$ = $L5$ = 7 mm, $L3$ =$L4$ = 9 mm, D = 19.42 mm, Wf = 1.975mm, Ws = 0.52mm. In this, one rectangle of 5mm has been removed from the patch in the first iteration. In this by applying different iterations self similar structures are obtained.

Parameter	value
Length of patch(L)	25.5mm
Width of patch(W)	20.5mm
Diameter(D)	19.42mm
Thickness of substrate	1.5mm
Dielectric Constant of substrate	4.4
Loss tangent of substrate	0.02
Width of Feed Line (Wf)	1.975mm
Length of Feed Line(Lf)	4.5mm

Table 1
Antenna dimensions

III. ITERATIONS

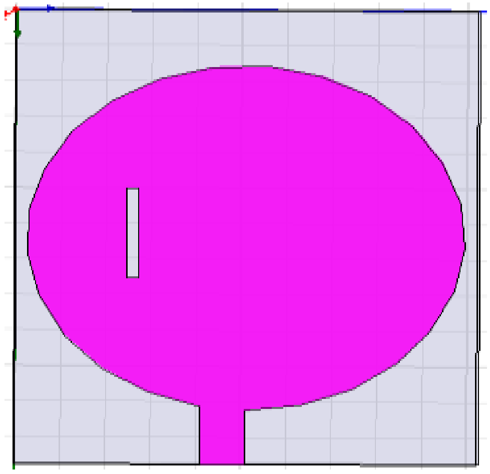


Fig. 2:1st iteration

This is the simple circular micro strip antenna with narrow rectangular shaped outer slot (L1) is cut into patch. In the first iteration one rectangle of dimension 5 mm has been cut from the patch as shown in figure2.

In this, arm of the vertical slot having width of 0.52mm.

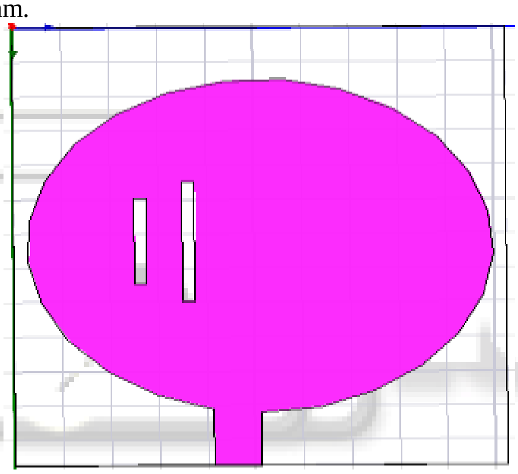


Fig. 3: 2nd iteration

After it, another narrow rectangular side slot (L2) is cut from the patch. In the second iteration, one rectangle having dimensions 7mm is cut from patch shown in figure3.

In this, arm of the vertical slot having width of 0.52mm.

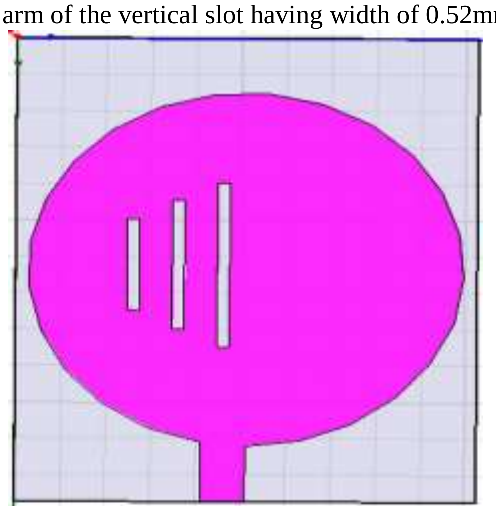


Fig. 4: 3rd iteration

In the third iteration further middle slot (L3) rectangle is cut from the patch. In third iteration, one rectangle having dimension 9mm is cut from patch shown in figure 4.

In this, arm of the vertical slot having width of 0.52mm.

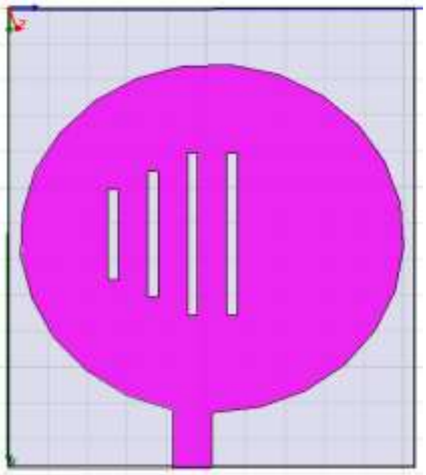


Fig. 5: 4th iteration

In the forth iteration further middle slot (L4) rectangle is cut from the patch. In this iteration, one rectangle having dimension 9mm is cut from patch shown in figure 5.

In this, arm of the vertical slot having width of 0.52mm.

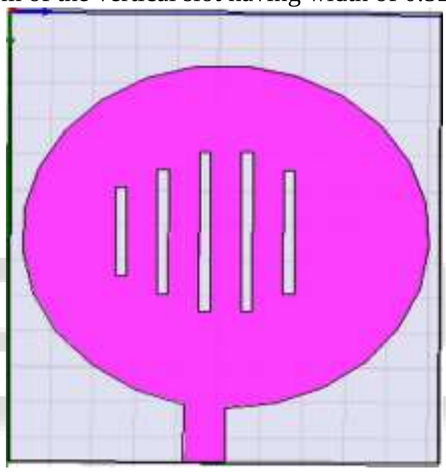


Fig. 6: 5th iteration

After it, narrow rectangular side slot (L5) is cut from the patch. In this iteration, one rectangle having dimension 7mm is cut from patch shown in figure 6.

In this, arm of the vertical slot having width of 0.52mm

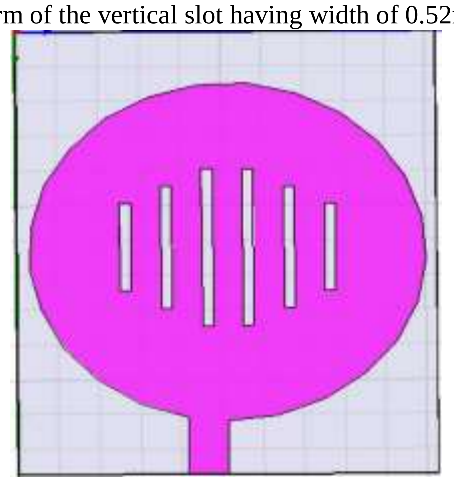


Fig. 7: 6th iteration

This is the circular micro strip antenna with narrow rectangular shaped outer final cut slot (L6) into patch. In this iteration one rectangle of dimension 5 mm has been cut from the patch as shown in figure7.

In this, arm of the vertical slot having width of 0.52mm.

IV. DESIGN REQUIREMENTS

There are three essential parameters for the designing of a micro strip antenna. Firstly, the resonant frequency (f_0) of the antenna must be selected.

Secondly, the dielectric material of the substrate (ε_r) selected for this design is FR- 4 Epoxy which has a dielectric constant of 4.4 and loss tangent is 0.02.The dielectric constant is important design parameter.

Lastly, substrate thickness is important design parameter. Thick substrate increases the fringing field at the periphery or the radiating patch

V. SIMULATION AND RESULTS

A. Return losses

The proposed antenna has constructed and studied. The return losses of the antenna are measured using an ansoft HFSS tool.

Figure 8 shows the simulated results of return losses in different iterations. In the last iteration return losses are -25db,-23db,-46.4db and -30db at 6.28Ghz, 7.3Ghz, 8.54Ghz and 10.18 GHz respectively.

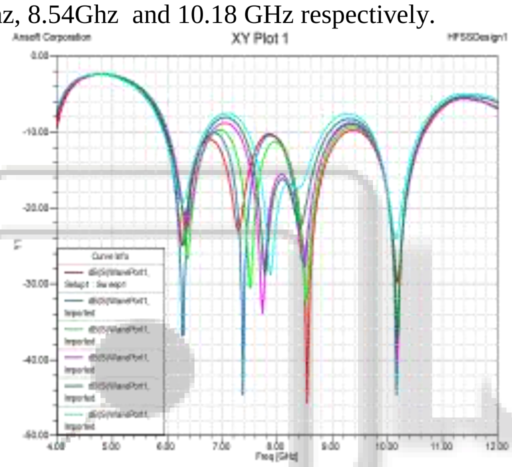


Fig. 8: Simulated results of return losses versus frequency

Iteration Number	Resonant Frequency(GHz)	Return Loss(db)
1st Iteration	6.3	-19
	7.8	-28
	8.4	-17.4
	10.16	-24
2nd Iteration	6.32	-20
	7.78	-28.8
	8.42	-22.6
	10.18	-37.6
3rd Iteration	6.36	-22
	7.74	-34
	8.48	-27
	10.18	-40
4th Iteration	6.36	-26
	7.52	-30
	8.52	-32
	10.18	-37
5th Iteration	6.28	-36
	7.38	-44
	8.48	-28
	10.16	-44
6th Iteration	6.28	-25
	7.3	-23
	8.54	-46.4
	10.18	-30

B. Effect of different feed Techniques

In **micro strip feed** the feed strip is of 1.975mm and this technique used to calculate their effect on performance. The conducting strip is connected directly to the edge of micro strip patch. Hence this is an easy feeding scheme, since it is provides ease of fabrication and simplicity in modeling as well as impedance matching. This feed is shown in Figure 9 and results are in Figure 10.

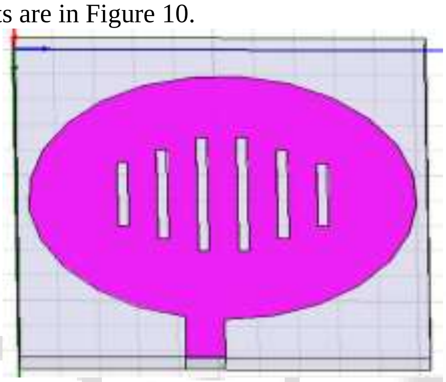


Fig. 9: Design of circular shaped antenna using Micro strip feed Technique

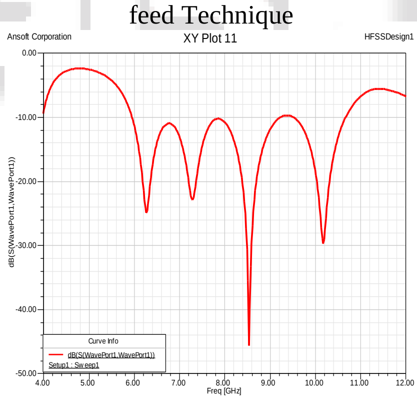


Fig. 10: Simulated results of circular shaped antenna using Micro strip feed versus frequency

Coplanar waveguide (CPW) feed allows easy fabrication of active devices due to presence of center conductor and close proximity of the ground planes. Here

The rectangles are the 8.5mm in width and 2.4 in length. This feed shown in Figure 11

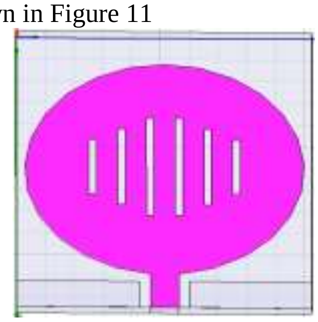


Fig. 11: Design of circular shaped antenna using CPW feed Technique

In **Inset feed** radiating patch and micro strip feed line are separated by the ground plane by cutting slots on either side of feed. Rectangle is of 3mm in width and 2.52 in length, then subtracted from the patch. In this Feed line is 1.975mm is in width and 5.52 in length, after this recombine the feed line by the Unite.

This feed shown in Figure 12

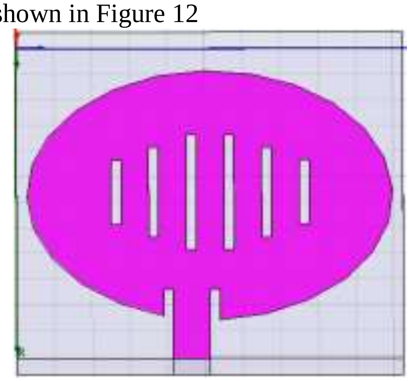


Fig.12: Design of circular shaped antenna using Inset feed Technique

Table 3 shows the return loss obtained from the different feed techniques of the patch antenna.

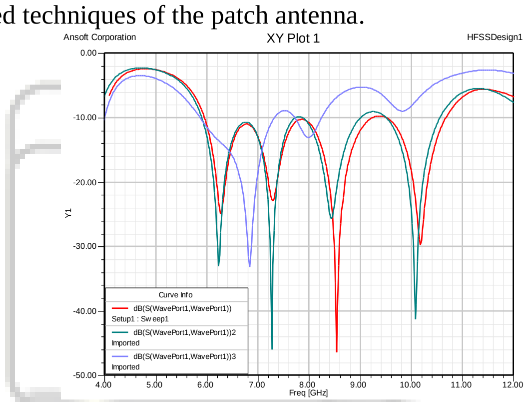


Fig. 13: Simulated results of different feeding techniques versus frequency

C. Effect of Ground plane modification

The proposed ground plane has introduced aa significant improvement in performance in the achieved operating band. Here Ground sizes are 25.5mm, 12.75mm, 5 mm.

Results shown in Figure 14.

Table 3 shows the return loss obtained from the different ground sizes of the patch antenna.

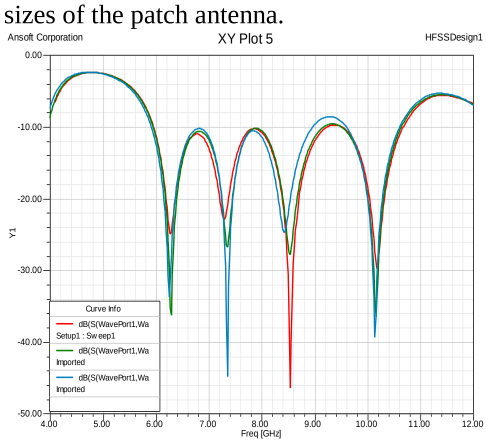


Figure 14 Simulated results of different ground size versus frequency

Factor	Name & Value(mm)	Resonant Frequency(GHz)	Return Loss
Feed technique	Micro strip	6.28	-25
		7.28	-23
		8.54	-47
		10.18	-30
	Cpw	6.2	-33
		7.2	-46
		8.4	-25
		10	-41
	Inset	6.8	-33
		8	-13
Feed Size	1.975	6.28	-25
		7.28	-23
		8.54	-47
		10.18	-30
	2.975	7.1	-27
		8.4	-22
		10	-34
	3.975	7	-26
		8.4	-25
		10.1	-44
Ground Size	25.5	6.28	-25
		7.28	-23
		8.54	-47
		10.18	-30
	12.75	6.3	-36
		7.3	-26
		8.5	-27
		10.1	-36
	5.0	6.2	-33
		7.3	-44
		8.4	-24
		10.1	-39

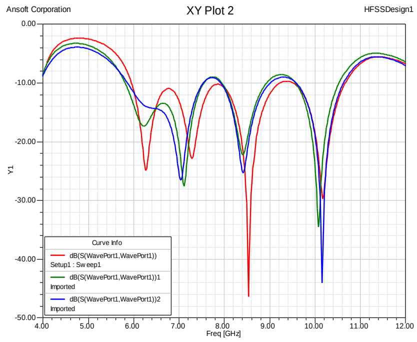
Table 3: Return losses at Variation of Ground size,Feed technique & size

D. Effect of Feed size of the proposed Antenna

The Feed Size is an important issue to be considered when designing a micro strip patch antenna.

Here different sizes are 1.975mm, 2.975mm, 3.975mm. Figure 15 shows the return loss graph obtained from the different feed sizes of the patch antenna.

Table 3 shows the return loss obtained from the different feed sizes of the patch antenna.



E. Radiation Pattern

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. Radiation properties include power flux density, radiation intensity, field strength, directivity, phase or polarization." The radiation property of most concern is the two- or three dimensional spatial distribution of radiated energy as a function of the observer's position along a path or surface of constant radius. In this paper, radiation pattern is taken in terms of gain (dB).Figure 16 shows the simulated results of radiation pattern at 0db and figure 17 shows the simulated results at 90 db.

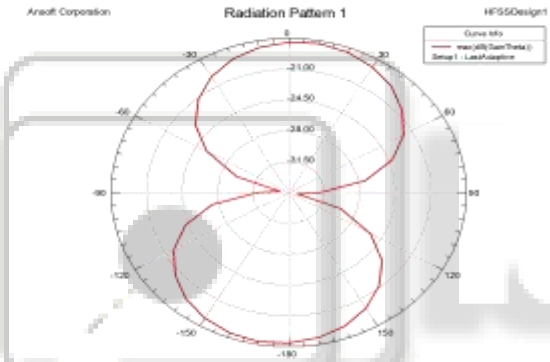


Fig. 16: Radiation Pattern at 0db

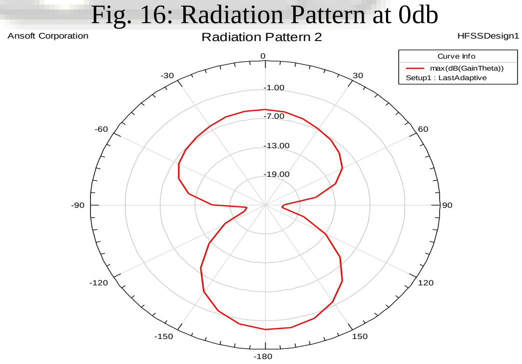


Fig. 17: Radiation pattern at 90 db

F. 3D polar plots

Figure 18 shows the 3D polar plot in terms of gain theta. This plot indicate the radiation intensity an gain of the antenna in different directions.

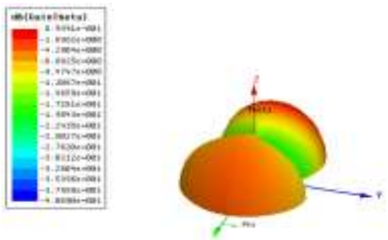


Fig. 18: 3D polar plots

G. VSWR

VSWR (voltage standing wave ratio) should be ≤2.In this design, VSWR ≤2 in 5.9-10.7 GHz frequency band.

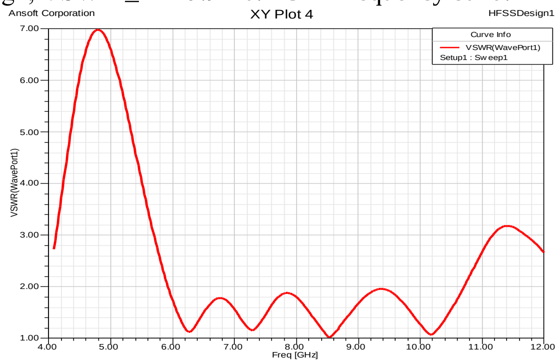


Fig.19: VSWR versus frequency

VI. CONCLUSIONS

In this paper Circular shaped patch antenna has been studied. In this micro strip feed line is used to excite the antenna. In this studied that as the number of iteration increases size of antenna is reduced. The proposed antenna resonates at 6.28 GHz, 7.28 Ghz,8.54Ghz and 10.18Ghz.VSWR≤2 in frequency band 5.9-10.7Ghz.In this studied that wideband antenna work for multiband applications. Bandwidth of proposed antenna is 10.434***%.*** It has several applications like satellite uplink communications, Wimax, Wireless applications (WLAN), radar applications and medical applications.

REFERENCES

[1] A Circularly Polarized Stacked Patch Aperture Coupled Micro strip Antenna for 2.6 GHz Band Arun Kumar & M. V. Kartikeyan, Springer Science + Business Media Published: 23 Jan2007
[2] Design of a Circular Polarization Switchable Micro strip Array Antenna using Magic-T Bias Circuit Md. Azad Hossain,Piyas Chowdhury,Quazi Delwar HossainEisuke Nishiyama and Ichihiko Toyoda, 978-1-4799-2299-4/13 2013IEEE
[3] Miniaturized Inverted Multiband Stacked Triangular Fractal Patch Antenna for Wireless Communication Sumit Kumar, Deepak Gangwar, R. L.yadava, 978-1-4799-2866-8/14 2014 IEEE.
[4] Constantine A. Balanis, Antenna Theory Analysis And Design,2005
[5] Model Updating and Structural Optimization of Circular Saw Blades with Internal Slots Wei-Hsin Gau, Kun-Nan Chen, and Yunn-Lin Hwang, Hindawi Publishing Corporation Volume 2014
[6] Inverted S-Shaped Compact Antenna for X-Band Applications M. Samsuzzaman and M. T. Islam, Hindawi Publishing Corporation Volume 2014.
[7] Modified Micro strip Aperture Coupled Patch Antenna with Sierpinski Fractal Geometry Hao Jiang, Weiming Li, and Zhenghui Xue, Hindawi Publishing Corporation Volume 2014.