Dual Band Slotted Microstrip P atch Antenna For Wireless Applications

Sushila Gupta*[1] and Esha Johari[2]

ABSTRACT

This paper describes dual-band patch antenna. The dual-band operation is obtained by embedding a pair of Lshaped slots. Dual band antenna can reduce the size of antenna 40%, comparing with rectangular microstrip antennas on normal dielectric substrate, and have wider bandwidths for both bands. In this paper L-shaped slots patch antenna with length L= 25.74 mm and width W = 31.20 mm fabricated based on availability of Rogers Duorid 5880 dielectric material and a prototype antenna is developed. The dielectric constant of Rogers Duorid 5880 material is $\varepsilon_r = 2.2$ *having thickness h = 0.16 mm and copper thickness is 35 microns using a coaxial feeding method for dual band operation. The prototype antenna is operating in S band frequency range.*

***Keywords** : gain, patch antenna, reflected power, Rogers Duorid* 5880, S band.

1. INTRODUCTION

The rapid increase in communica tion standards has led to great demand for antenn as with low real estate, low profile and size, low cost of fabrication and ease of integration with feeding ne twork [1-2]. Microstrip patch antennas are widely used due to its advantages such as low profile configurat ion, relative low cost, and ease of construction that can be produced in great quantity by printed circuit te chnology and the possibility of wrapping the antenna around objects using flexible substrates. On the other hand, this antenna posses several disadvantages includin g narrow bandwidth and low gain [3-5]. Hence, many re searchers have been studying these disadvantages w ith a focus on improving performance of patch antenna parameters and achieving compactness.

A microstrip antenna in its si mplest form consists of a radiating patch on one si de of a dielectric substrate and a ground plane on the othe r side.

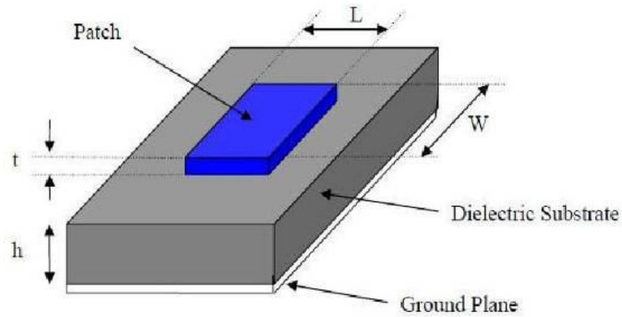


Fig.1. Microstrip Antenna Configuration

- Patch: present the radiant con ductive element and which can take several forms.
- Substrate: allows to isolate b oth conductive planes, Characterized by the permittiv ity.
- Ground plane: conductor situat ed below the circuit on which is placed the substra te.

2. METHODOLOGY ADAPTED

Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric

1.* Sushila Gupta, Department of E lectronics & Communication, S. R.M.S.C.E.T Bareilly, India. e -mail : sushila.gupta784@gmail .com
2. Esha Johari, Department of Ele ctronics & Communication, S.R. M.S.C.E.T Bareilly, India. e-m ail : eshajohari.ec07@gmail.co m

constant is desirable since this provides better efficiency, larger bandwidth and better radiation.

The preferred models for the analysis of microstrip patch antennas are the transmission line model, cavity model, and full wave model (which include primarily integral equations/Moment Method). The transmission line model is the simplest of all and it gives good physical insight.

2.1Method of Analysis

Transmission line model represents the microstrip antenna by two slots of width W and height h separated by a transmission line of length L. The microstrip is essentially a non homogeneous line of two dielectrics, typically the substrate and air.

In Figure 2, most of the electric field lines reside in the substrate and parts of some lines in air. As a result, this transmission line cannot support pure transverse electric magnetic (TEM) mode of transmission, since the phase velocities would be different in the air and the substrate. Instead, the dominant mode of propagation would be the quasi-TEM mode. Hence, an effective dielectric constant (ε_{reff}) must be obtained in order to account for the fringing and the wave propagation in the line [6-7].

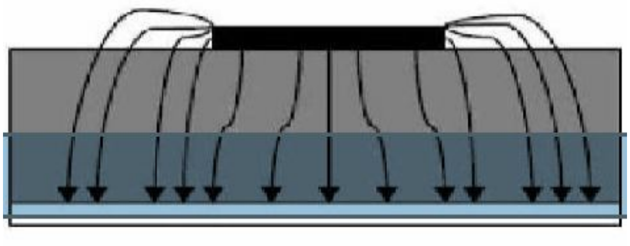


Fig.2. Electric Field Lines

The value of (ε_{reff}) is slightly less then ε_r because the fringing fields around the periphery of the patch are not confined in the dielectric substrate but are also spread in the air as shown in Figure 2 above.

$$\varepsilon_{reff} = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_{r-1}}{2}\left[1+12\frac{h}{w}\right]^{-\frac{1}{2}} \qquad (1)$$

Where,

ε_{reff} = Effective dielectric constant

ε_r = Dielectric constant of substrate

h = Height of dielectric substrate

w = Width of the patch

Consider Figure 3 below, which shows a rectangular microstrip patch antenna of length L, width W resting on a substrate of height h. The co-ordinate axis is selected such that the length is along the x direction, width is along the y direction and the height is along the z direction.

In order to operate in the fundamental TM10 mode, the length of the patch must be slightly less than $\lambda/2$ where λ is the wavelength in the dielectric medium and is equal to $\lambda_0/\sqrt{\varepsilon_{reff}}$ where λ_0 is the free space wavelength. The TM10 mode implies that the field varies one $\lambda/2$ cycle along the length, and there is no variation along the width of the patch. In the Figure 4 shown below, the microstrip patch antenna is represented by two slots, separated by a transmission line of length L and open circuited at both the ends. Along the width of the patch, the voltage is maximum and current is minimum due to the open ends[9]. The fields at the edges can be resolved into normal and tangential components with respect to the ground plane.

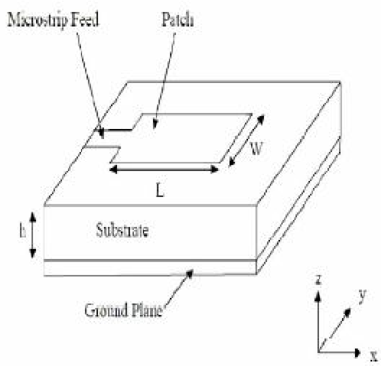


Fig.3. Microstrip Patch Antenna

S-JPSET : ISSN : 2229-7111, Vol. 6, Issue 1

It is seen from Figure 5 that the normal components of the electric field at the two edges along the width are in opposite directions and thus out of phase since the patch is $\lambda/2$ long and hence they cancel each other in the broadside direction. The tangential components (seen in Figure 5), which are in phase, means that the resulting fields combine to give maximum radiated field normal to the surface of the structure. Hence the edges along the width can be represented as two radiating slots, which are a part and excited in phase and radiating in the half space above the ground plane.The fringing fields along the width can be modeled as radiating slots and electrically the patch of the microstrip antenna looks greater than its physical dimensions. The dimensions of the patch along its length have now been extended on each end by a distance Δ L.

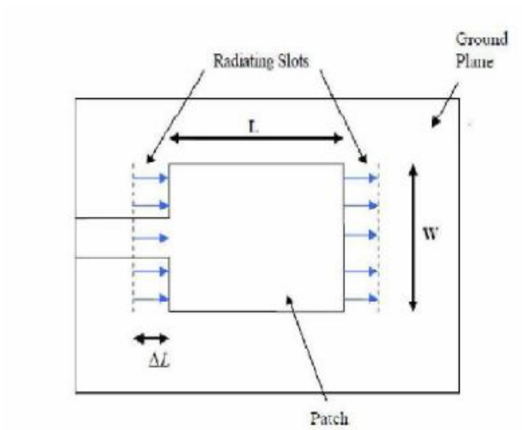


Fig. 4. Top View of Antenna

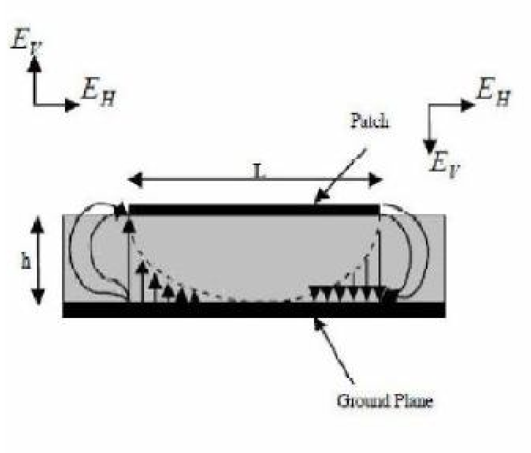


Fig.5. Side View of Antenna

$$\Delta L = 0.412 \times h \frac{(\varepsilon_{reff} \pm 0.3)}{(\varepsilon_{reff} - 0.258)} \frac{\left(\frac{w}{h} + 0.264\right)}{\left(\frac{w}{h} + 0.8\right)} \quad (2)$$

The effective length of the patch L_{eff} now becomes:

$$L = L + 2\Delta L \quad (3)$$

For a given resonance frequency f_0, the effective length is:

$$f_0 = \frac{c}{2\sqrt{\varepsilon_{reff}}} \left[\left(\frac{m}{L}\right)^2 + \left(\frac{n}{w}\right)^2 \right]^{\frac{1}{2}} \quad (4)$$

Where, m and n are modes along L and W respectively. For efficient radiation, the width W is:

$$w = \frac{c}{2 f_0 \sqrt{\frac{\varepsilon_{r+1}}{2}}} \quad (5)$$

2.2 Feed Point

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As seen from Figure 6, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

The feed co-ordinates were calculated $Y_f = W/2$ and $X_f = X_0\ \Delta L$

Where,

$$X_0 = \frac{L}{\pi} \cos^{-1} \sqrt{\frac{50}{z_0}} \quad (6)$$

$$z_0 = \sqrt{50 \times z_{in}} \quad (7)$$

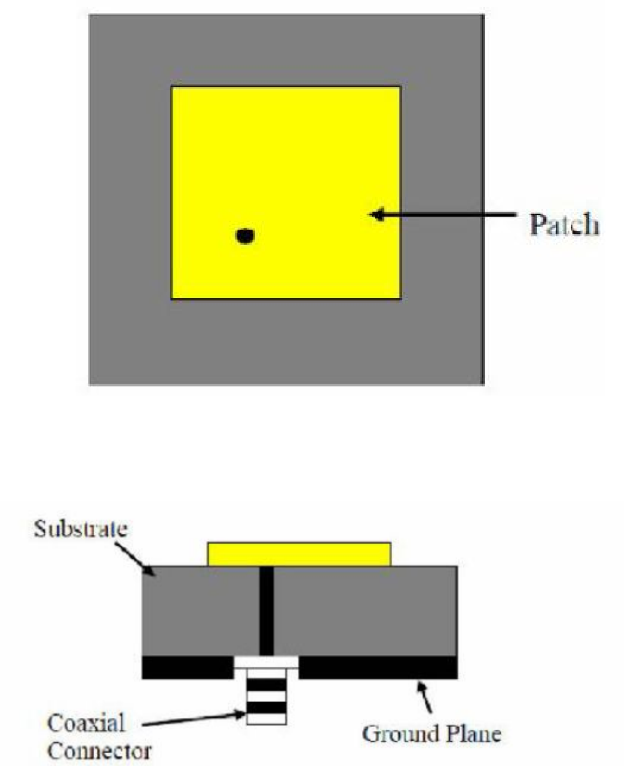


Fig.6. Coaxial Feed

The main advantage of this typ e of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation.

2.3 Dielectric Substrate

Considering the trade-off between the antenna dimensions and its performance , it was found suitable to select a thin dielectric su bstrate with low dielectric constant. Thin substrate permits to reduce the size and also spurious radiation as surface wave and low dielectric constant for higher bandwidth, better efficiency and low power loss.

3. ANTENNA DESIGN

3.1 Slotted Rectangular Patch Antenna

In this paper, the two L slot is cut in microstrip patch for wide band width. L-shaped slots easily formed by cutting two slots fr om a rectangular patch. By cutting the slots from a pa tch, gain and bandwidth of microstrip antenna can be enhanced by using substrate RT Rogers Duroid 5880 of thickness 1.6 mm and conductor is copper of 35 microns.

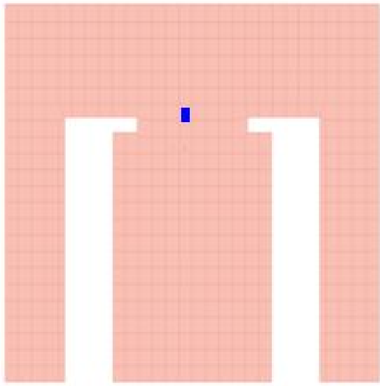


Fig.7. Layout of slotted Patch Antenna

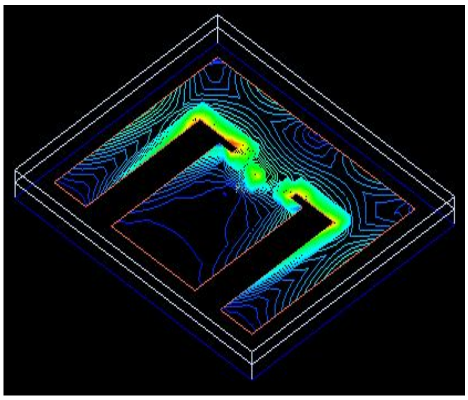


Fig.8. 3D view of slotted Patch Antenna

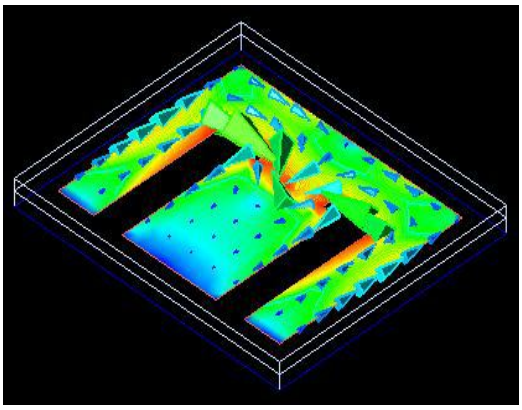
The figure shows the layout an d 3D view of slotted patch antenna with embedding a pair of L-shaped slots with appropriate length and width.

4. RESULTS AND DISCUSSION

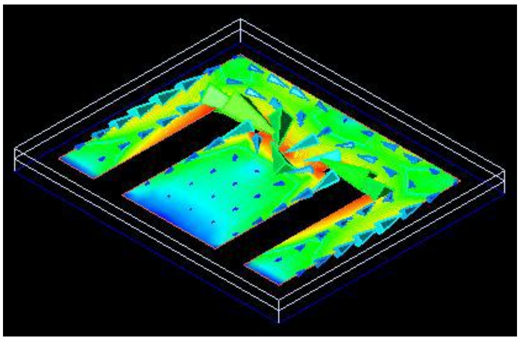
For the Simulation of proposed antenna Agilent ADS software have been used. I n this simulation we have tried to obtain optimized performance of various antenna parameters such as ret urn loss, gain, radiation pattern, directivity etc. With the help of Agilent ADS software we can also calculate the bandwidth percentage. With the proposed antenna we have

S-JPSET : ISSN : 2229-7111, Vo l. 6, Issue 1

achieved a very appreciable pe rcentage of bandwidth which could be useful for the wireless communication as well as application in S ba nd



(a)



(b)

Fig.9. Radiation Intensity of Slotted Patch Antenna

From the figure radiation intensity of slotted patch antenna at different time inst ants can be observed.

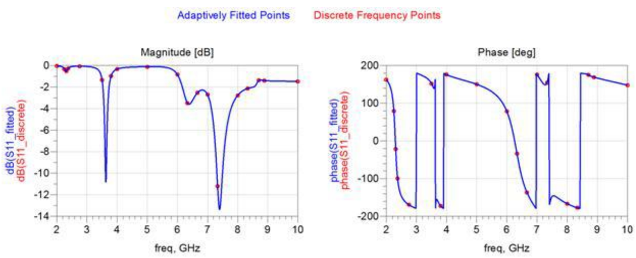


Fig.10. S11of slotted Patch Antenna

From the plot it can be observed that return loss at frequency 7.5GHz is maximum which is near by -13dB.

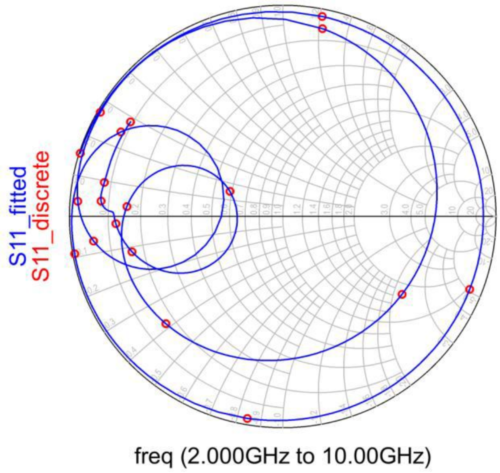


Fig.11. Smith Chart of Slotted Patch Antenna

The figure shows the smith chart of slotted patch antenna.

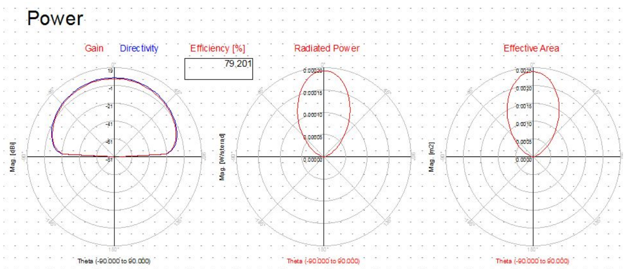


Fig.12. Far Field Parameter of Slotte d Patch Antenna

The polar plot represents the directivity (7.85468), efficiency (79.201%), gain (6. 84199dbi) and power radiated (.000399234watts) of antenna.

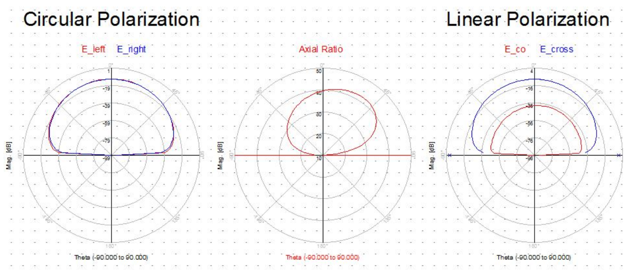


Fig. 13. Polarization of Slotted Patch Antenna

The polar plot represents the liner and circular polarization with axial ratio occurred by coaxial feed point.

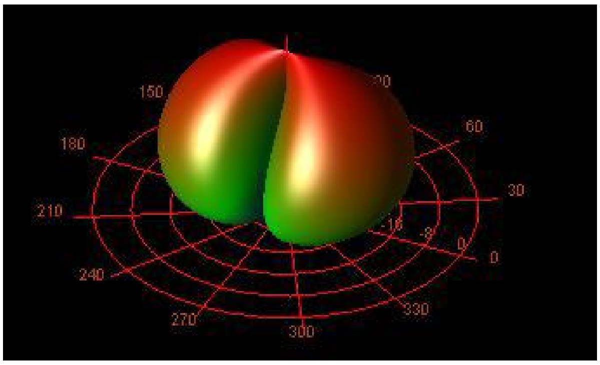


Fig.14. Eφ of slotted Patch Antenna

The figure shows the radiation pattern of slotted patch antenna in terms of E_{φ}

Power radiated (Watts)		0.000399234
Effective angle (Steradians)		2.05941
Directivity(dBi)		7.85468
Gain (dBi)		6.84199
Maximim intensity (Watts/Steradian)		0.000193859
Angle of U Max (theta, phi)	2	78
E(theta) max (mag,phase)	0.375851	-163.426
E(phi) max (mag,phase)	0.0692896	-160.125
E(x) max (mag,phase)	0.0111392	176.065
E(y) max (mag,phase)	0.381797	-163.302
E(z) max (mag,phase)	0.013117	16.5737

Fig.15. Performance Parameter of Slotted Patch Antenna

The figure represents the diff erent parameter of slotted patch antenna occurred by coax ial feed.

5. CONCLUSION

From the simulated results, it is clear that the proposed antenna exhibited a c ompactness of 77 % with omni directional radiation characteristics. Proposed antenna resonates at two frequencies 3.6 GHz and 7.4 GHz signifying dua l frequency. This dual frequency behavior increases i ts applications in radar and satellite communications. Although the gain of the antenna is high and efficiency is also high. Hence, the proposed patch antenna is a lo w cost, moderate gain antenna solution for various S- band wireless applications. The different parameter of pair of L-shaped slot patch antenna is t he directivity (7.85468), efficiency (79.201%), gain (6. 84199dbi) and power radiated (.000399234watts).

REFERENCES

[1] Sushila Gupta , Design a H shaped Patch Antenna For Wireless Communication, ISSN (Print) : 2278-8948, Volume-2, Issue-2,2013

[2] E. Wang, J. Zheng and Y. Liu, a novel dual-band patch antenna for wlan Communication, *Progress In Electromagnetics Research C, Vol. 6, 93-102, 2009*

[3] Kin-Lu Wong. *Compact and Broadband Microstrip Antennas*. John c Wiley&Sons, Inc, 2002.

[4] Svezhentsev, A. Y.,Some far field features of cylindrical microstrip antenna on an electrically small cylinder," Progress In Electromagnetic Research B, Vol. 7, 223-244, 2008.

[5] Abbaspour, M. and H. R. Hassani, \Wideband star-sharped microstrip patch antenna," Progress In Electromagnetic Research Letters, Vol. 1, 61{68, 2008.

[6] Constantine A. Balanis. *Antennas Theory - Analysis and Design*. 3rd Edition. John Wiley&Sons, Inc, 1997.

[7] Yi Huang and Kevin Boyle. *Antennas from Theory to Practice*. John Wiley&Sons, Inc, 2008.

[8] John D. Kraus. *Antennas*. 2nd Edition. McGraw Hill International, 1988.

[9] Punit S. Nakar. Design of a compact microstrip patch antenna for use in wireless/cellular devices. Master's thesis, The Florida State University, 2004.

[10] A.B.Mutiara,"Design of microstrip antenna for wireless communication at 2.4 GHz", *International Journal of Computer and Electrical Engineering*, Vol. 3, No. 5, October 2011

