International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-4, November 2019

# Bandwidth Enhanced Multislot Rectangular Patch Antenna for UWB and X Band Wireless Applications

**S.Sivagnanam, E.Gnanamanoharan, G.Ramprabhu, M.Monica**

***Abstract:*** ***The main aim of this work is to design a compact Rectangular shaped Multislot patch antenna for Ultra Wide Band (UWB) and X band applications. The proposed antenna has a condensed size of 35*30*1.6mm$^3$. The antenna consists of a rectangular patch with microstrip line feed etched on FR4-epoxy substrate with dielectric constant of 4.4. To improve the bandwidth, circular slots are made in patch and the ground plane. The proposed antenna achieves wide bandwidth of 12.7GHz (3.3-16 GHz) having four resonance frequency with good return loss and maximum gain of 9.64dBi. The antenna is designed, simulated and analyzed by using HFSS (High Frequency Structural Simulator). The charisma of this design is that it employs single patch that makes it easy to fabricate and cost-effective as well.***

***Keywords: Multislot patch antenna, circular slot, FR-4 substrate, HFSS Tool, wide bandwidth, UWB.***

## I. INTRODUCTION

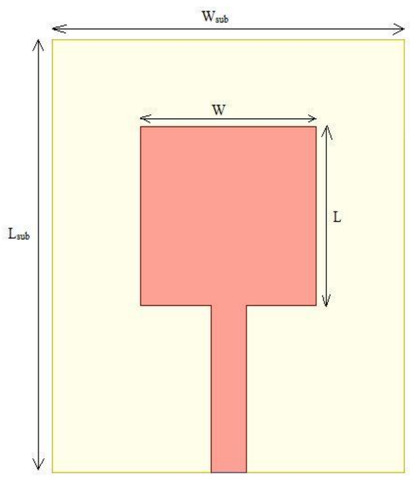
The rapid growth in wireless communication fashioned enormous demands for Ultra wide band and X band antennas to persuade high gain and large bandwidth covering all frequency ranges for these systems.

In 2002, FCC permitted the Frequency range of UWB Communication is from 3.1–10.6 GHz with maximum radiated power of -41.3 dBm / MHz and data transfer rate between 100–200 Mbps (FCC, 2002). The benefits of the UWB are high data rate, less interference, more secure, low cost and less complexity. The UWB is used for many applications such as radar, imaging in medicine, military communication and satellite communication. The frequency range of X-band is between 8.2 GHz to 12.4 GHz and it's used for radar and satellite communication.

In the past years, plenty of UWB antennas have been presented for various applications. In the proposed design Multislot rectangular patch antennas with defected ground plane have been used for enhanced bandwidth [1].The monopole antennas and slot antennas are more suitable candidates for UWB antennas. Circular disc monopole antenna [2] and coplanar waveguide [3] have been studied. Other typical shapes of UWB monopole antennas have been discussed, such as half-disc [7], hexagon [6] and rectangle [5]. The antenna was designed with different shapes namely elliptical [4], Honeycomb shaped antenna [11], U-shaped microstrip patch antenna [12]. There are numerous techniques is employed to design the microstrip antenna with dual band [10], multiband [9] and broad band properties [8] to analyze the functional parameters such as return loss, gain and bandwidth.

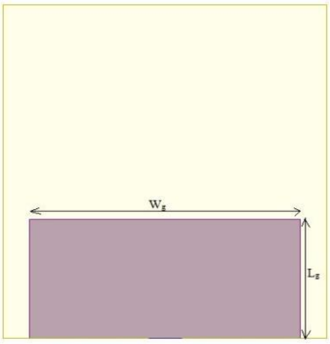
## II. ANTENNA DESIGN

The antenna is mainly constructed on the substrate called FR4-epoxy of height 1.6mm. In the proposed antenna initial design, the rectangular shaped patch with microstrip line feed and the partial ground plane is used. Fig 1.Shows the initial antenna designs of the proposed work. The Optimized dimensions of the proposed antenna shown in Table 1. This basic structure gives the narrow bandwidth of 2.8GHz (3.3-6.1GHz) as shown in fig 3.




(a)

Manuscript published on November 30, 2019.
* Correspondence Author
**S.Sivagnanam*,** Department of ECE, Annamalai University, Annamalainagar, Tamilnadu, India. sivadots@gmail.com.
**Dr.E.Gnanamanoharan,** Department of ECE, Annamalai University, Annamalainagar, Tamilnadu, India. gnanamanohar@gmail.com.
**G.Ramprabhu,** Department of ECE, Annamalai University, Annamalainagar, Tamilnadu, India. ramprabhug18@gmail.com.
**M.Monica,**PG Scholar, M.E. (Communication Systems), Department of ECE, Annamalai University, Annamalainagar, Tamilnadu. India. monica24mohan@gmail.com

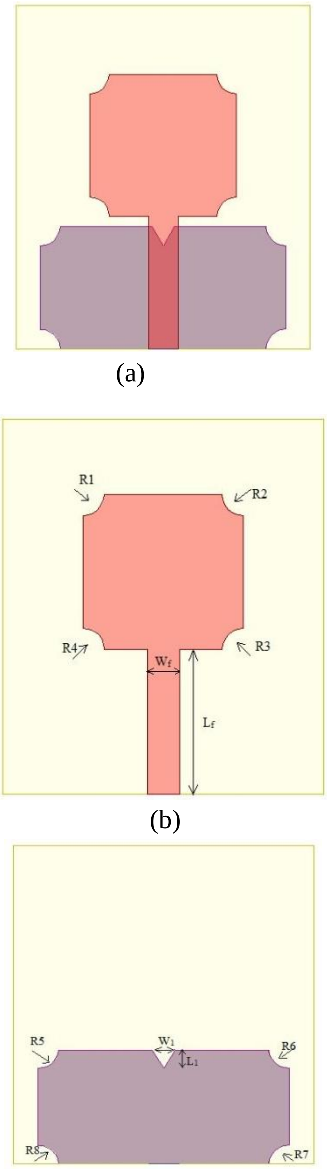



(b)

**Fig. 1. Basic structure (a) front view (b) back view**

Further, to enhance the bandwidth, the following work is carried out in the proposed design.

- ❖Different radiuses of circular slot are introduced in the each corner of the patch.
- ❖Different radiuses of circular slot are introduced in the each corner of the ground plane.
- ❖Additional triangular slot is introduced in the ground plane.




(a)

(b)

(c)

**Fig. 2.(a) Proposed antenna (b) front view (c) back view**

**Table 1. Optimized Geometrical Dimensions of a Proposed Antenna Design.**

| Symbols | Value(mm) | Symbols | Value(mm) |
|---|---|---|---|
| L | 14.5 | $W_f$ | 25 |
| W | 15 | $L_g$ | 12.5 |
| $L_{sub}$ | 35 | $W_g$ | 25 |
| $W_{sub}$ | 30 | $L_1$ | 2 |
| $L_f$ | 13.5 | $W_1$ | 2.3 |

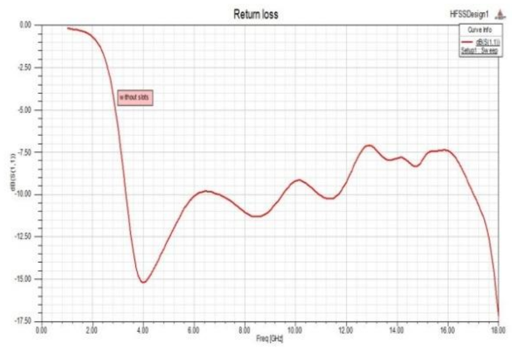



**Fig. 3. Return loss for basic structure.**

***2.1 Effect of various radius of circular slot in patch***

To improve the antenna bandwidth and matching, circular slots are added to the each corner of the rectangular patch as shown in fig 2(b). Fig 4 shows the return loss for various radiuses of circular slots in the patch. From the return loss curve, it can be observed that the 2mm radius circular slot gives the wide bandwidth of 11.2GHz (3.3 – 14.5GHz).

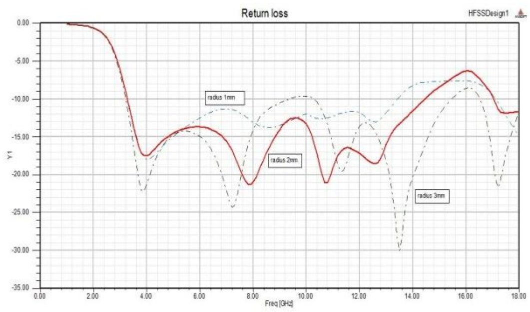



**Fig. 4. Return loss due to various radius of circular slots in patch**

***2.2 Effect of various radius of circular slots in ground plane***

Further to improve bandwidth of the proposed design, circular slots are taken in the top and bottom corners of the optimized ground plane as shown in the fig 2(c). Fig 5 shows the return loss for various radiuses of circular slots taken in the ground plane. From the return loss curve, it can be observed that the 2mm radius circular slots in the ground plane give the increased bandwidth of 12.3GHz (3.3 – 15.6GHz).

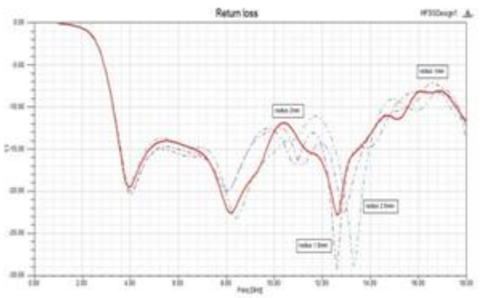


**Fig. 5. Return loss due to various radius of circular slots in ground plane**

***2.3 Effect of various length of triangular slots in ground plane***

In the optimized defected ground plane is modified by adding triangular slot as shown in fig 2(c). The slot is taken in various lengths to get the enhanced bandwidth than the existing work. Fig 6 shows the return loss for triangular slots in various lengths. Here length 2mm gives the maximum bandwidth of 11.5GHz (3.3 – 14.8GHz).

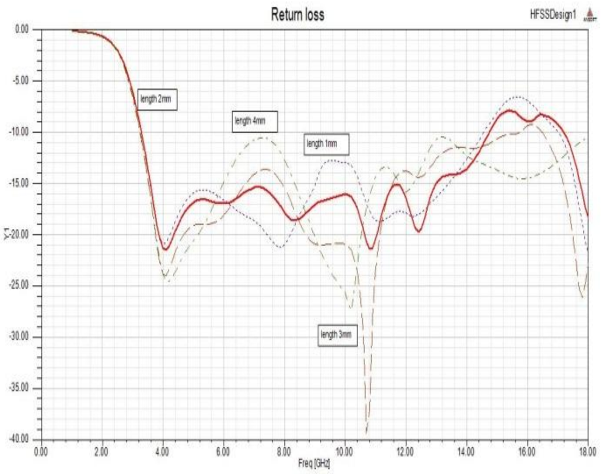



**Fig. 6 . Return loss due to various lengths of triangular slots in ground plane.**

## III. SIMULATED RESULTS AND DISCUSSION

In the proposed antenna design, the distance between the patch and the ground plane increases by adding the circular slots at the each corner of the bottom of the rectangular patch, which tunes the capacitive coupling between them and slots in the upper corners of the patch tunes the inductive part of the antenna that neutralizes the capacitive coupling between the ground plane and the patch to get pure resistive input impedance.

In the proposed antenna design circular slots is introduced in both the patch and ground plane of radius 2mm (R1= R2= R3= R4= R5= R6= R7= R8=2mm) and also additional triangular slot in ground plane as shown in fig.2 (a). The proposed antenna simulated results shows better impedance matching and wider bandwidth when adding circular and triangular slots in the ground plane. Fig.7 shows the return loss of microstrip patch antenna. The return loss of the proposed antenna is -21.08dB at 4GHz, -19.82dB at 8.5GHz, -20.02dB at 11.2GHz and -23.37dB at 12.9GHz. Fig.8 depicts the VSWR for proposed antenna. At all resonant frequencies the value of VSWR is less than 2.Table 2.Shows the comparison of bandwidth and gain of the proposed antenna with other existing antenna.

**TABLE 2: Comparison of Bandwidth and Gain of Existing and Proposed Design.**

| Parameters | Existing work | Proposed work |
|---|---|---|
| Bandwidth | 8.28GHz<br>(3.42 - 11.7GHz) | 12.7GHz<br>(3.3 – 16GHz) |
| Gain | 6 dB | 9.64 dB |

To further analyze the characteristics of proposed design 3D radiation pattern for all resonant frequencies are simulated and is shown in fig 9. It is observed that the proposed antenna design has bidirectional radiation pattern. Fig.10 shows maximum gain of antenna is 9.64dB at f = 4GHz. A polar plot of Gain Theta and Gain Phi in Fig 10.(a), (b), (c) and (d) respectively is also shown to understand the variation with change in Theta and Phi.

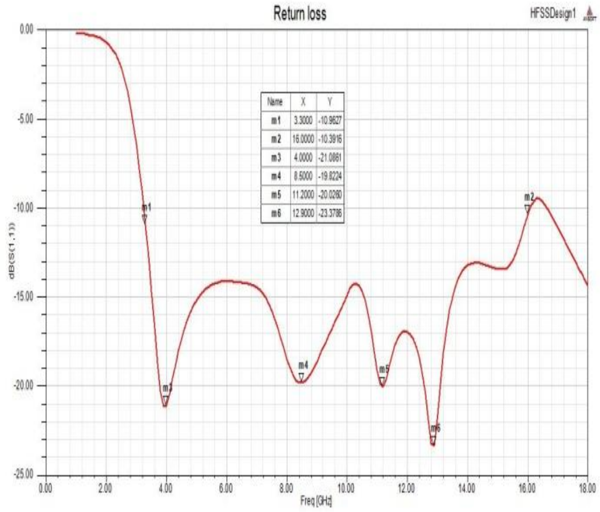



**Fig. 7. Return loss for proposed antenna design**

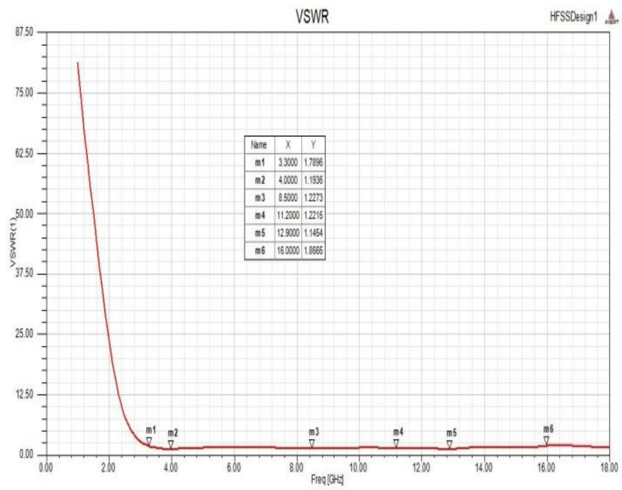
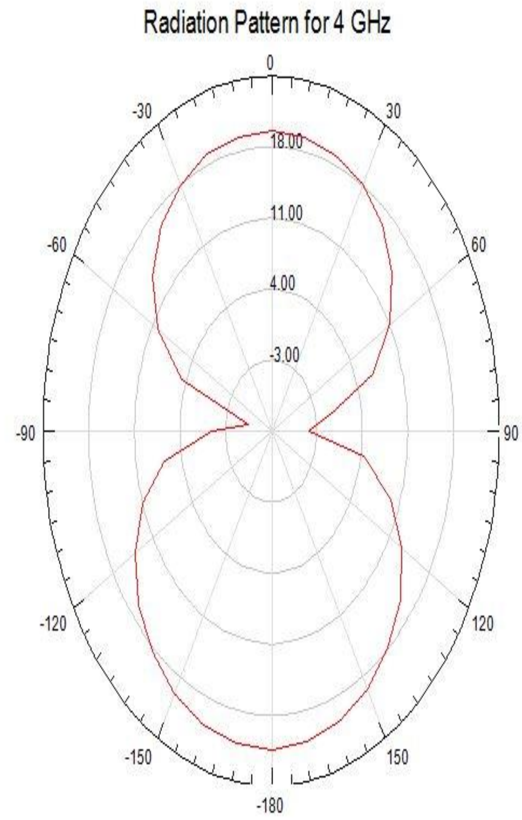



**Fig. 8. VSWR for proposed antenna design**

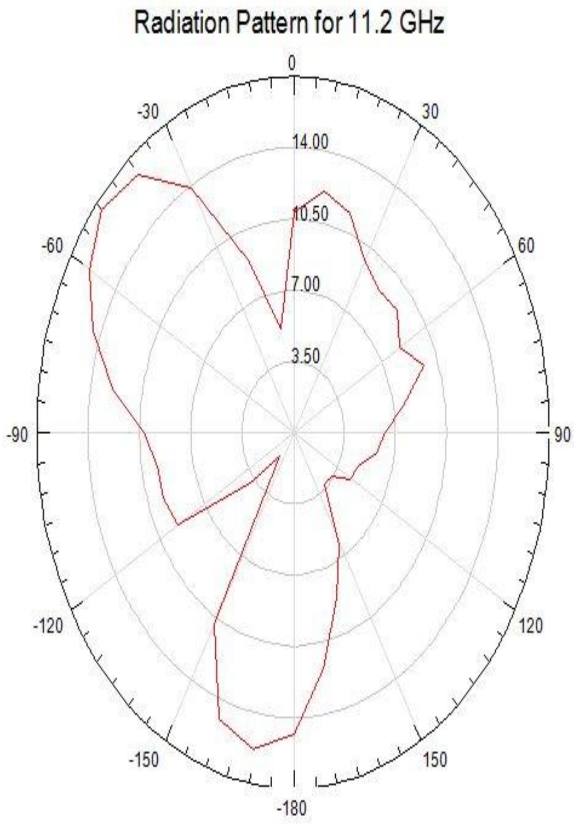
*Retrieval Number: C6477098319/2019©BEIESP*
*DOI:10.35940/ijrte.C6477.118419*
*Journal Website: www.ijrte.org*



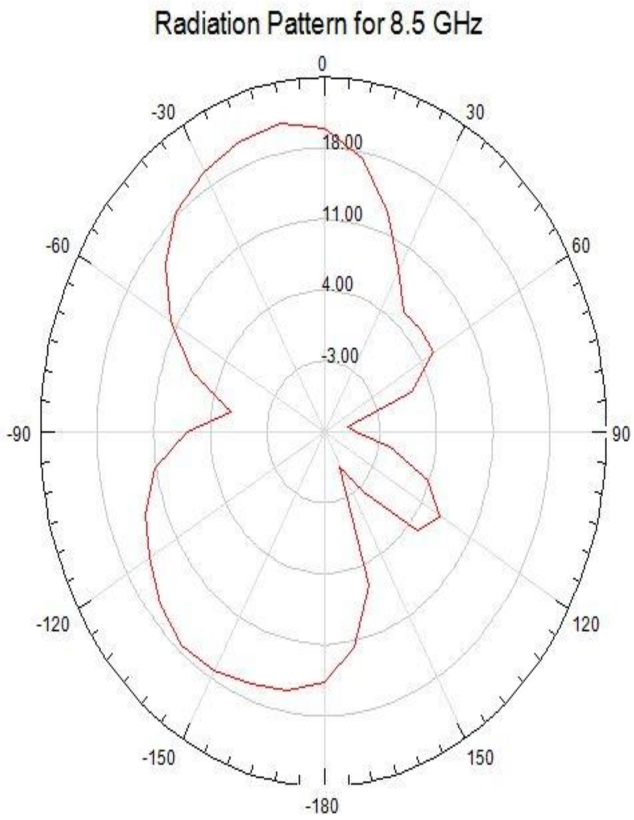
*Published By:*
*Blue Eyes Intelligence Engineering*
*& Sciences Publication*



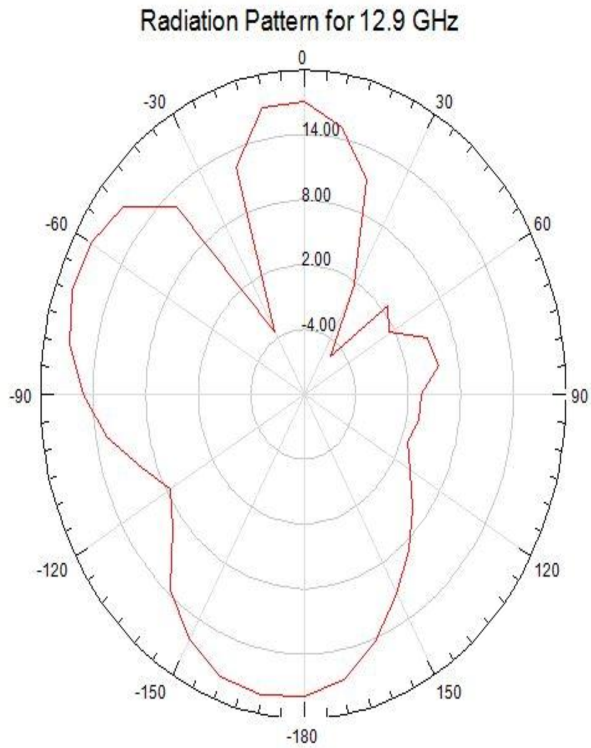

(a)




(c)

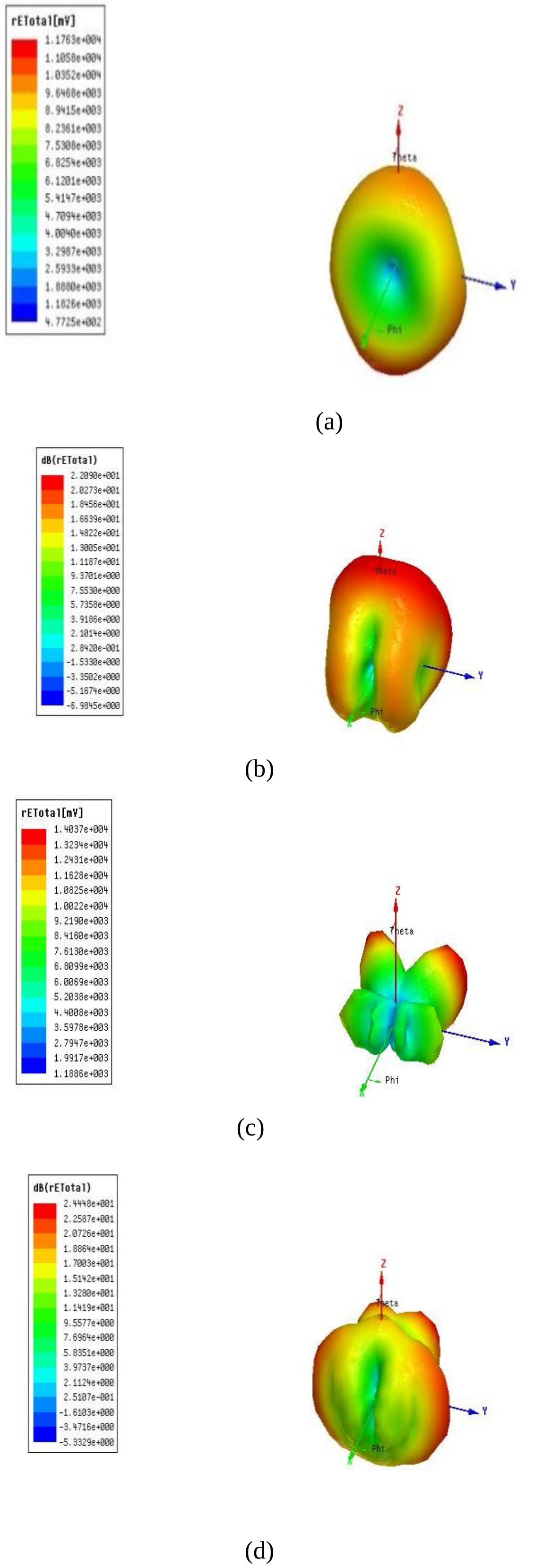



(b)




(d)

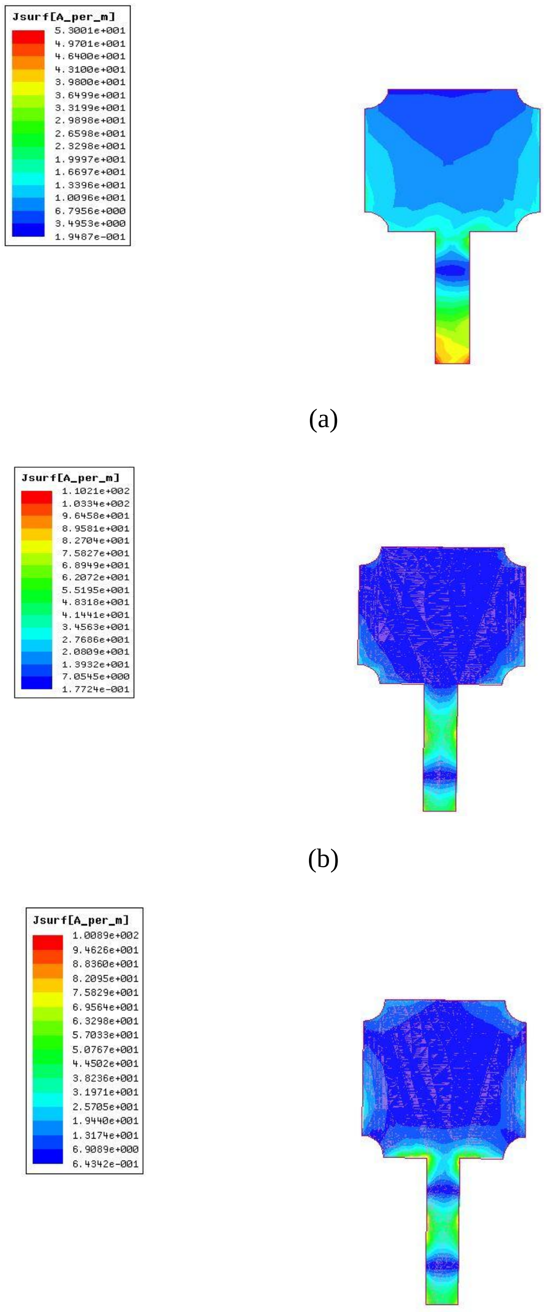
**Fig. 9. Radiation pattern of different resonant frequencies**



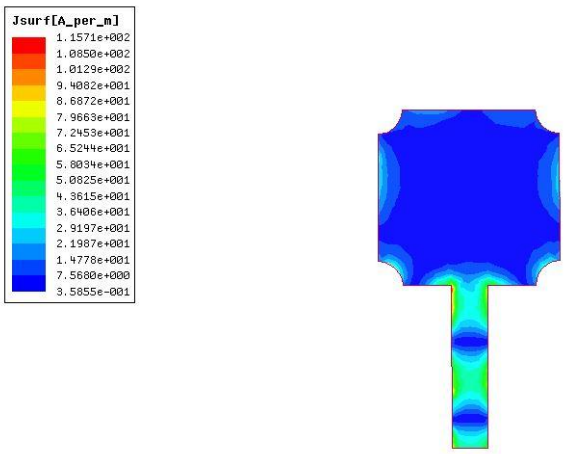

(a) (b) (c) (d)

**Fig. 10. Gain variation of proposed antenna at (a) f = 4GHz, (b) f = 8.5GHz, (c) f =11.2GHz, (d) f = 12.9GHz**

The surface current distribution of the proposed antenna at different resonating frequencies is shown in Fig. 11. From Fig. 11(a) it can be observed that at 4GHz the surface current is distributed in the upper part of the patch and from fig 11(b), (c) and (d) it is observed that the current is evenly distributed along the patch at 8.5GHz, 11.2GHz and 12.9GHz.




(a) (b) (c)




(d)

**Fig. 11. Surface current distribution at (a) 4GHz (b) 8.5GHz (c) 11.2GHz (d) 12.9GHz**

## IV. CONCLUSION

A compact Multislot microstrip patch antenna is proposed and designed for UWB, C band and X band wireless applications. The proposed antenna has the overall bandwidth of 12.7 GHz with four resonance frequency of 4GHz, 8.5GHz, 11.2GHz and 12.9GHz respectively. The characteristics of the proposed antenna namely return loss, VSWR, surface current distribution, gain and radiation pattern are investigated using HFSS design tool. The resonant frequencies of 4GHz is used in downlink from space to earth (3.4GHz to 4.2GHz), 8.5GHz is used in military requirements for land and naval radars (8.5GHz to 10.5GHz), 11.2GHz is used in fixed satellite service from space to earth (10.7GHz to 11.7GHz), 12.9GHz is used in space research (12.7GHz to 13.25GHz) and also used in wi-fi and WLAN. Hence the proposed antenna is most suitable for UWB, C and X band wireless applications.

## REFERENCES

1. Noor M. Awad, Mohamed K. Abdelazeez, “Multislot microstrip antenna for ultra-wide band Applications” journal of King Saud University – Engineering Sciences (2018) 30, 38–45.
2. Md Maqubool Hosain, Sumana kumara “Design of circular disc monopole antenna for UWB systems”, International conference on Microelectronics. Computing and communication systems ,pp 339-352.
3. Dong - min Deng; Hong - Xing Zheng, “A Design of an Ultra wideband Coplanar waveguide Antenna”, International Journal of Engineering Research & Technology, ISSN:2278-0181, vol. 4 Issue 07, July-2015.
4. Manisha Gupta; Vinita Mathur “ Multiband Multiple Elliptical Microstrip Patch Antenna with Circular Polarization” International Journal of wireless personal communications, volume 102, Issue 1, pp 355-368, September 2018.
5. K.P.Ray; S.S.Thakur; R.A.Deshmukh “ Broadbanding a printed rectangular monopole antenna” in 2009 Applied Electromagnetics Conference IEEE, March 2010, doi:10.1109/AMEC.2009.5430695.
6. K.P.Ray; S.Tiwari “Ultra wideband printed hexagonal monopole antennas”, in IET Microwave, Antennas & Propagation, vol 4, Issue 4, April 2010, pp 437-445, doi:10.1049/iet-map.2008.0201.
7. Ahmed Abdelraheem; Mahmoud Abdelraheem Abdalla “Compact curved half circular disc monopole UWB antenna”, in International Journal of Microwave and Wireless Technologies”,doi:10.1017/S17590787 14001 524.
8. Melad Olaimat; Aws Al- Qaisi “Novel design of broadband patch antenna for wireless communication application(1800MHz and 2400MHz)”International Journal of computer networks & communication, vol 7, no 3, May 2015
9. K.A.Amal; Subin Joseph; Sree Kumariamma; Ajoy kumar Mondal; R.Ratheesh “ Compact multiband microstrip patch antenna for wireless application”, in 2016 International Conference on Communication Systems and Networks IEEE, January 2017,doi:10.1109/CSN.2016.7824005.
10. Satish Shelke; V.U.Deshmukh “ Dual band microstrip patch antenna for wireless application” in IJSRST, vol 2, Issue 2, ISSN:2395-6011.
11. Ushaben Keshwala; Sanyog Rawat; Kanad Ray “Honeycomb shaped fractal antenna with defected ground structure for UWB applications”, International Conference on Signal processing and Integrated Networks©2019 IEEE.
12. Sumathi K, Abirami M, Divyabharathi P, “Multiband U shaped patch for C and S band applications”, International Journal of Innovative and Exploring Engineering, ISSN:2278-3075, vol 8, issue-4S, February 2019.

## AUTHORS FROFILE

**Mr. S.Sivagnanam,** received the B.E degree in Electronics and Communication Engineering from Manonmaniam Sundaranar University, Tirunelveli, Tamilnadu, India and M.E degree in Process Control and Instrumentation Engineering from Annamalai University, Annamalainagar, India. He is currently working as Assistant Professor of ECE at Annamalai University, Annamalainagar, India. His research interest is Design of Microstrip Patch Antenna for UWB wireless Applications and Microwave Engineering.

**Dr. E.GNANAMANOHARAN,** received the B.E degree in Electronics and Communication Engineering from Madras University, Chennai, Tamilnadu, India and M.E degree in Process Control and Instrumentation Engineering and Ph.D degree in Electronics and Communication Engg from Annamalai University, Annamalainagar, India. He is currently working as Assistant Professor of ECE at Annamalai University, Annamalainagar, India. His areas of interest include communication networks, wireless mobile ad hoc networks and wireless sensor networks. He has published 13 papers in various international journals.

**Mr.G.Ramprabhu,** received the B.E degree in Electronics and Communication Engineering from Madras University, Tamilnadu, India and M.E degree in VLSI Design from Anna University, Guindy, Chennai, India. He is currently working as Assistant Professor of ECE at Annamalai University, Annamalainagar, India. His areas of interest include VLSI Design, Communication Networks and Microwave Engineering.

**M.Monica,** received the B.E. degree in Electronics and Comminication Engineering from Agni college of technology, chennai,Tamilnadu, India. She is currently perusing her M.E. degree in communication systems in Annamalai university, Chidathambaram, Tamilnadu. Her research interest is Design of Microstrip Patch Antenna for UWB wireless Applications.