L-Slots Square Antenna for Octa-band Applications

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doi: https://doi.org/10.21467/proceedings.114.39

Abstract

The objective of this paper is to design an Octa- Band L-slot Square Patch antenna which will operate in 3.18 GHz, 4.71 GHz, 7.04 GHz, 8.38 GHz, 8.86 GHz, 10.66 GHz, 11.76 GHz, 14.12 GHz frequencies. The same antenna would also work in UWB frequencies. An L-slots Square copper patch with a thickness 0.035mm is placed on FR4 epoxy substrate having dielectric constant 4.4 with a height of 1.6 mm with single port. This has been designed using HFSS commercial software simulator so that Return Loss, VSWR, Radiation pattern and Surface current distribution can be measured.

Keywords: Octa-Band, L-slots, Radiation Pattern, Return Loss, Gain.

1 Introduction

In 1953[1], Deschamps introduced microstrip antenna concept and its research got importance in early 1970. With the success of this research work, in modern world microstrip antennas are found worldwide in the field of communication system in the military, medical, cellular application etc. because of its very lightly weight, cheap fabrication cost, smaller size, easy to design. It comes in different sizes and geometrical shapes[2-6]. This type of antenna can be used in various applications if it has more than a single resonance frequency. Hence many antennas can be replaced by this antenna[12]. An unconventional design is proposed here for the microstrip patch antenna using ANSYS HFSS version 15 software [7].

Here the antenna length and width are taken 39.6mm each. The number of L-slots is eight and one square box is excited by a lumped port. The port position is enhanced to obtain eight resonance frequencies with seven bands having a return loss less than -10dB. A detailed try & error methods study have been conducted to obtain the perfect position of the port so that they produce adequate return loss. We also observe that it produces acceptable radiation pattern at all resonance frequencies.

2 Antenna Design

An L-slot Square microstrip antenna having 39.6mm in each side with 8 L-Slots is excited with one lumped port. The ground is in square shape having both length and width of 49.2mm. The lumped port having rectangular shape is designed at a dimension of 1.67mm x 3mm. The height of the substrate is 1.6 mm. The ground & patch is assigned with copper material with a thickness of 0.035mm. So, Total height of the antenna is 1.67mm. The substrate is made of FR4 epoxy material and its permittivity is (εr) = 4.4 and its loss tangent is (δ) =0.02.

Proceedings DOI: 10.21467/proceedings.114; Series: AIJR Proceedings; ISSN: 2582-3922; ISBN: 978-81-947843-8-8

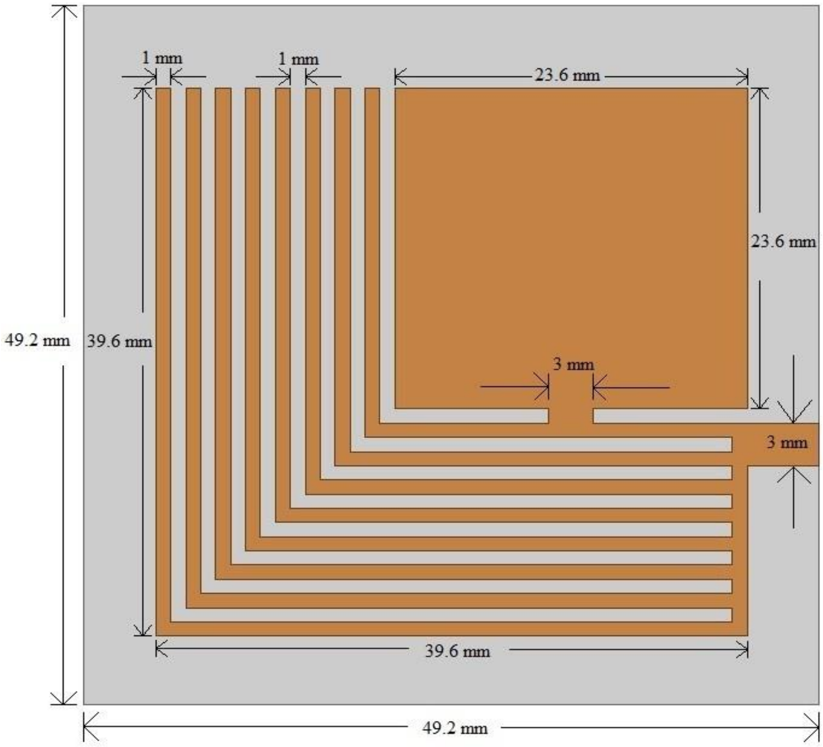

Fig1. Patch of the antenna placed on substrate of εr = 4.4

3 Process of Simulation

This antenna is simulated in different port positions to obtain the maximum possible number of resonance frequency bands. We use try and error method to shift the port to get the maximum return loss at resonant frequency. After observing all the results of each probe position, it was found that the port positions (18.5mm away from center of the patch in both the directions along X-axis) provided the best result of seven bands.

4 Results

At suitable port positions (18.5mm away from center of the patch in both the directions along X-axis), the proposed antenna generated nine bands of resonant frequencies. The frequency bands and their respective center frequencies, return loss, VSWR and application is listed below in TABLE 1.

TABLE 1

Frequency Bands (GHz)	**Centre Frequency (GHz)**	**S11 (dB)**	**VSWR**	**Applications**
3.16-6.67	3.18	-16.03	1.37	1. WIMAX. 2. 5G Network.
	4.71	-34.98	1.67	1. Military fixed and mobile communication. 2. Point-to-point microwave links and telemetry.

Proceedings DOI: 10.21467/proceedings.114
ISBN: 978-81-947843-8-8
Series: AIJR Proceedings
ISSN: 2582-3922

6.98-7.14	7.04	-21.58	1.07	1. Satellite Communication
8.25-8.61	8.38	-17.33	1.33	1. X-Band Applications
8.68-8.98	8.86	-16.13	1.37	
10.12-11.12	10.66	-27.47	1.08	
11.51-12.13	11.76	-23.71	1.39	
12.64-18	14.12	-44.70	1.01	1. Space and Satellite Applications

Graph of the results of the antenna for S11, VSWR, Radiation Pattern are shown below.

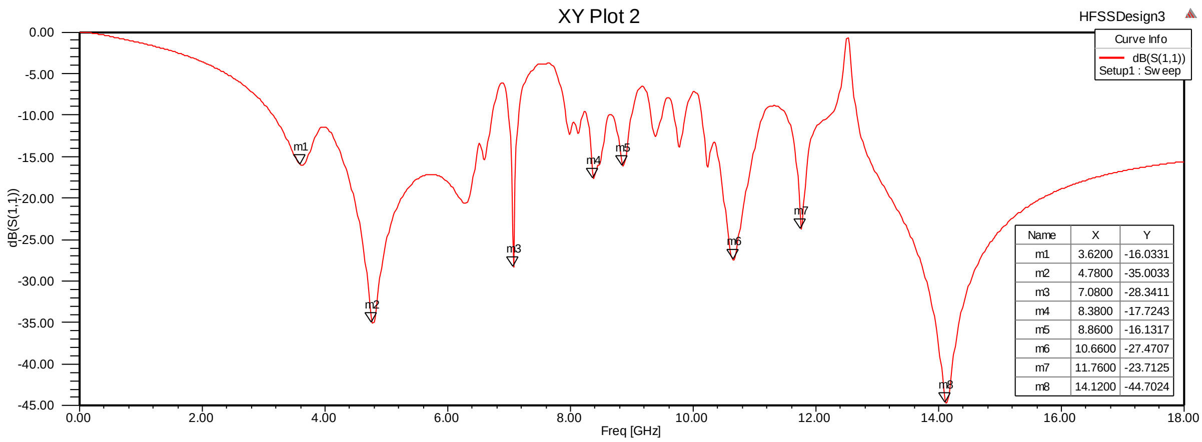

Fig2: S11 Parameter

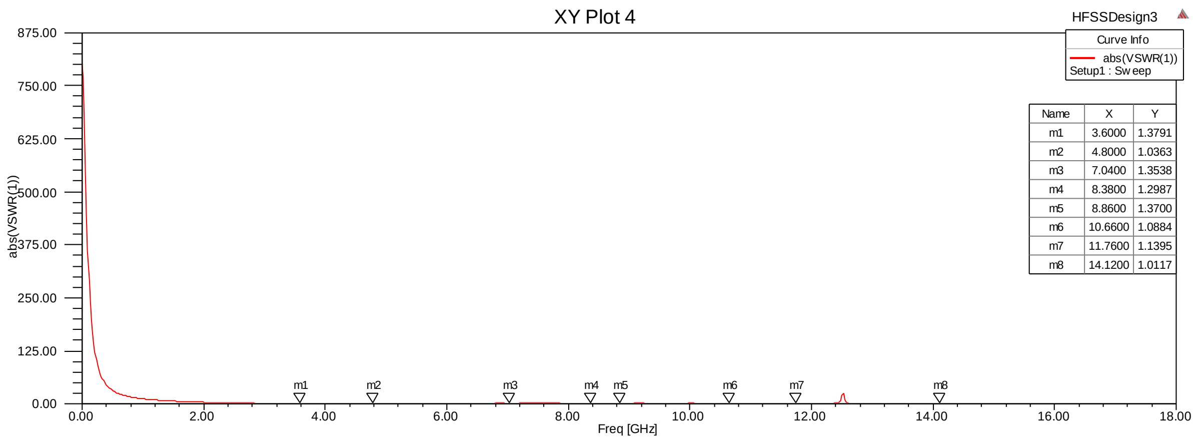

Fig3: VSWR

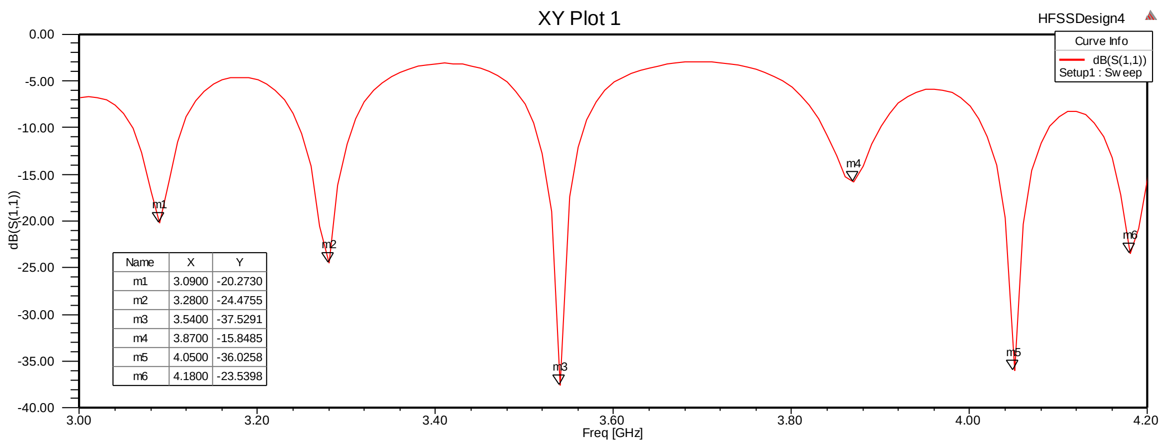

Fig 4: S11 Parameter between 3-4.2 GHz

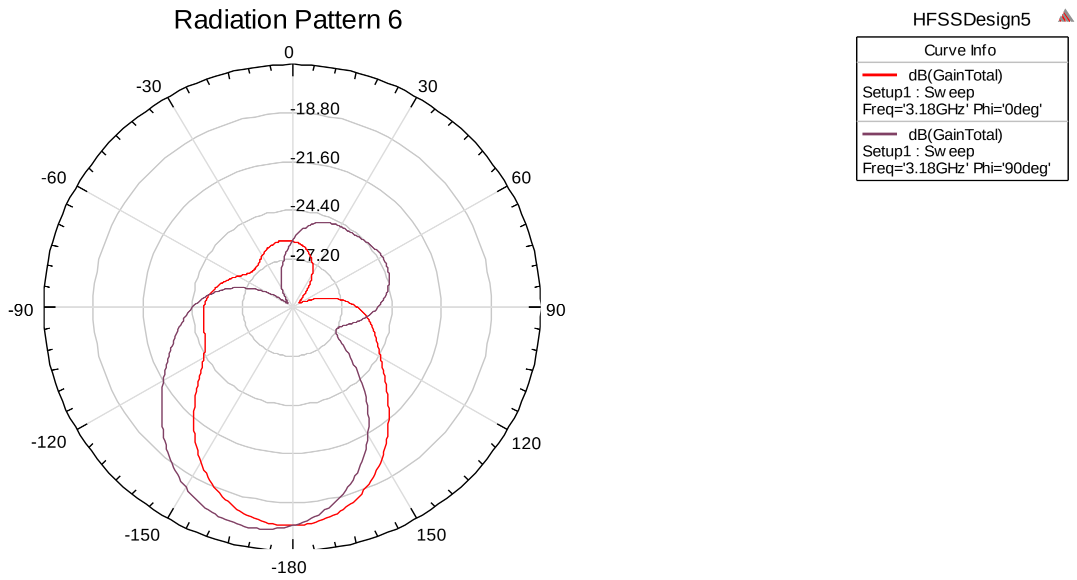

Fig 5: Radiation pattern for 3.18GHz

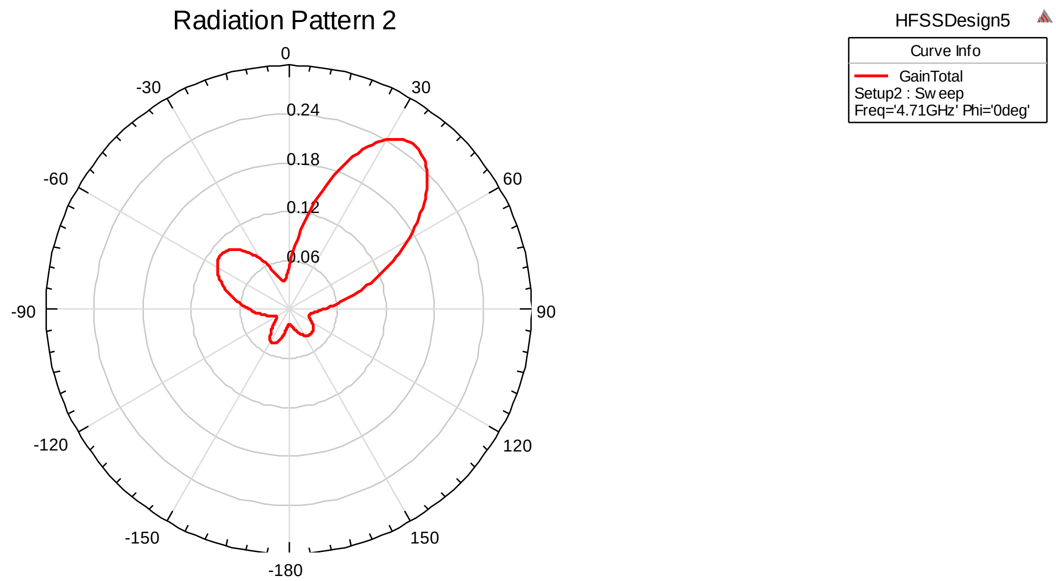

Fig 6: Radiation pattern for 4.71GHz

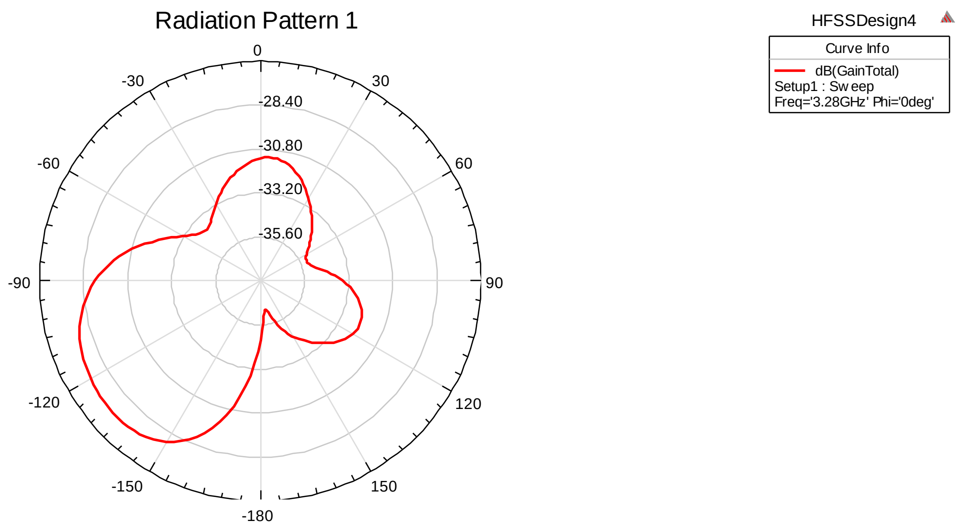

Fig 7: Radiation pattern for 3.28 GHz

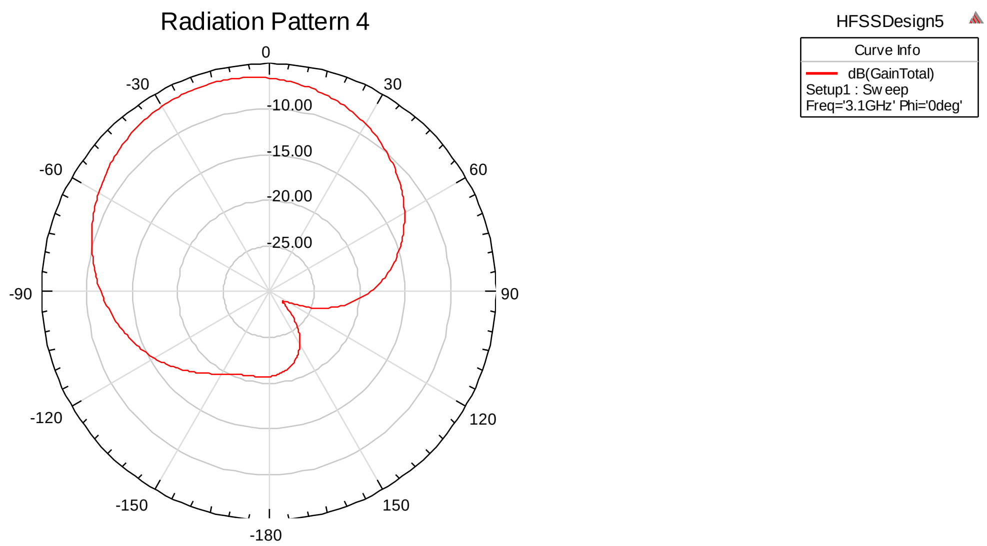

Fig 8: Radiation pattern for 3.1 GHz

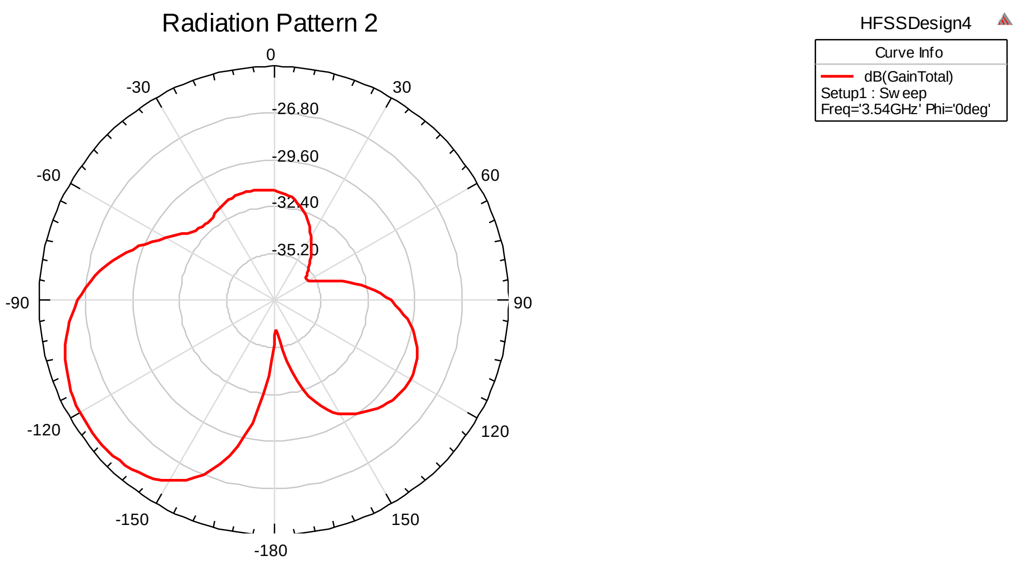

Fig 9: Radiation pattern for 3.54GHz

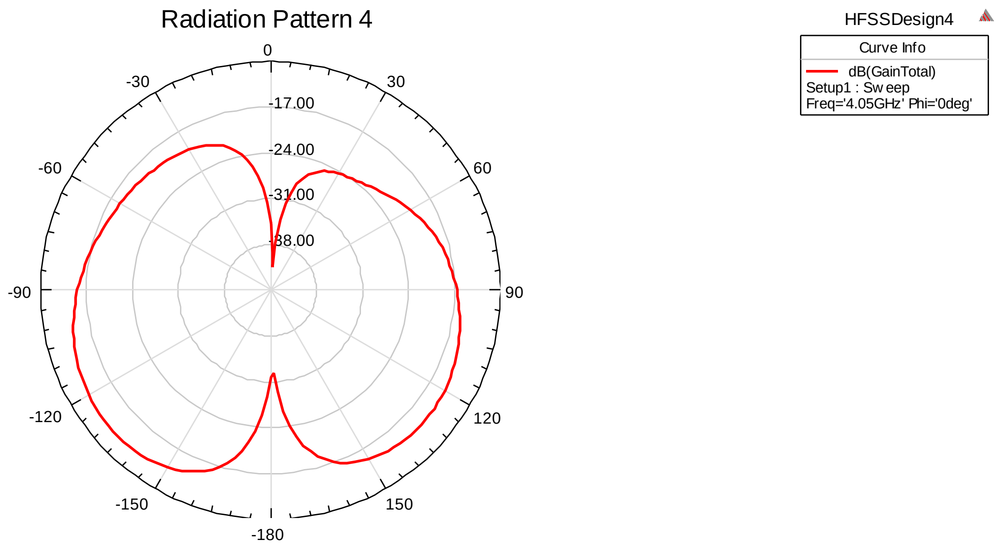

Fig 10: Radiation pattern for 4.07 GHz

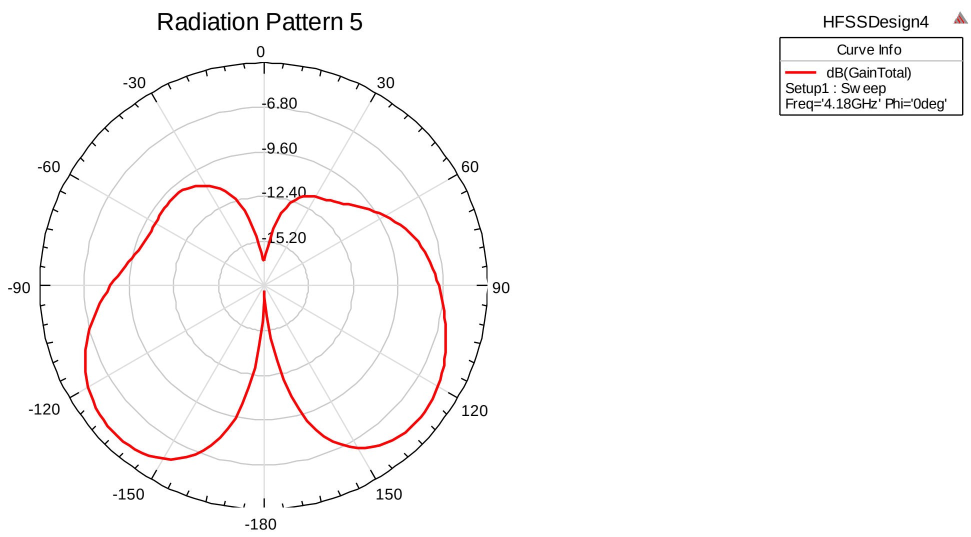

Fig 11: Radiation pattern for 4.18 GHz

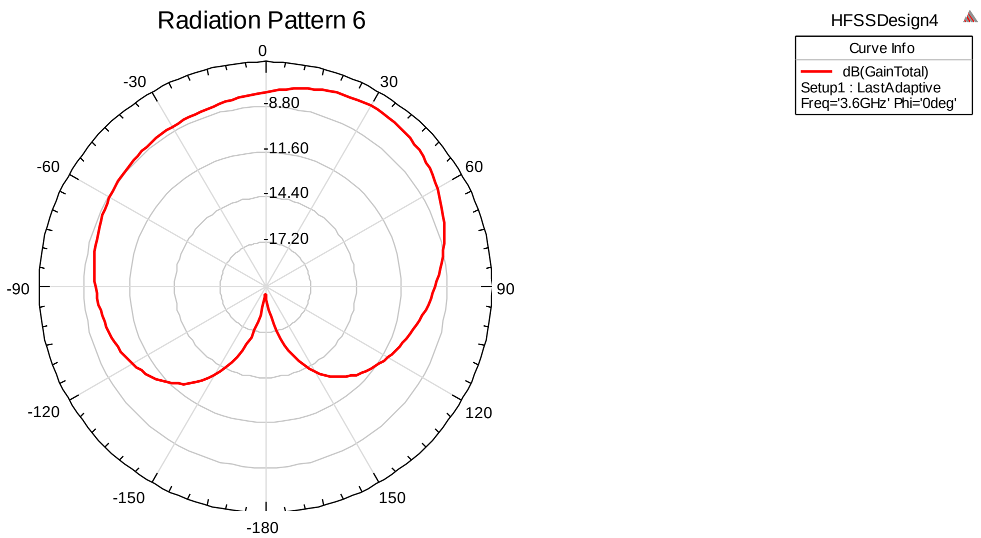

Fig12: Radiation pattern for 3.6 GHz

ISBN: 978-81-947843-8-8
ISSN: 2582-3922

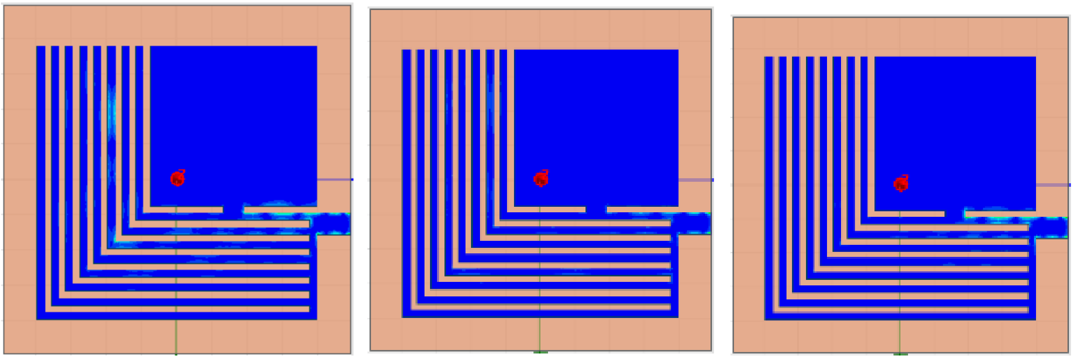

Fig13: Surface Current Distribution at 3.6GHz, 7.04GHz, 14.12GHz, respectively

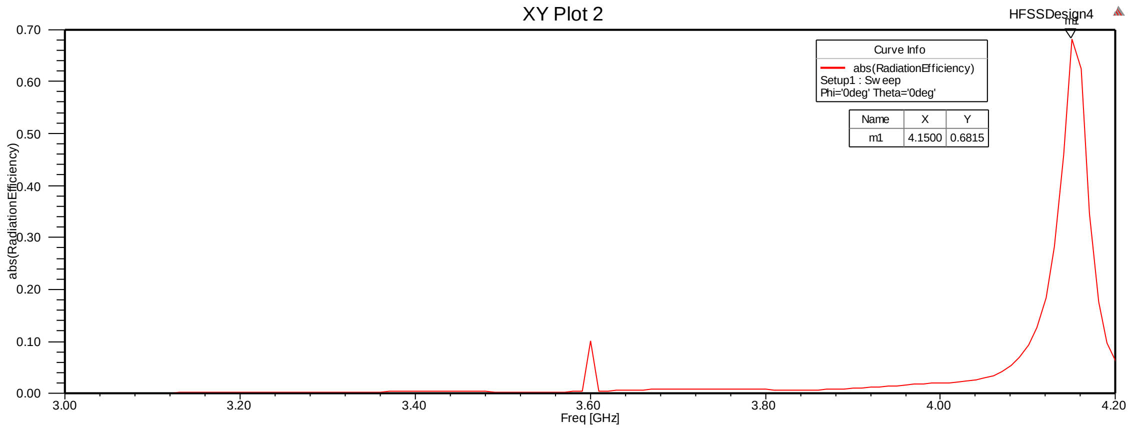

Fig 14: Radiation Efficiency at 4.15 GHz = 68.15%

The Radiation efficiency at the frequency 4.15 GHz is found to be 68.15%. So, at this frequency it is found that the wavelength is λ_0=72.29 mm. In this regard, Frequency Scalability can be determined, which is listed below in the TABLE 2.

TABLE 2

Frequency (GHz)	**λ_0 (mm)**	**gl**	**pl**	**Sql**
4.15	72.29	0.6806 λ_0	0.5478 λ_0	0.32646 λ_0

Where, gl is the length of the square ground, pl is the length of the square patch & Sql is the length of the square excluding the L-slots of the patch.

5 Conclusion

In this research work, the designed antenna Octa-Band L-Slots square shaped microstrip patch antenna is simulated by ANSYS HFSS version 15.0 for measurement of S11, VSWR, Surface Current Distribution and Radiation Pattern. The dimension of the square shaped Octa L-Slot antenna having each side 39.6 mm with 8 L-Slots was excited with one lumped port. The ground is in square shape having both length and width of 49.2mmhas been studied to obtain the perfect position of the port so that they produce adequate return loss.

6 Acknowledgement

We whole-heartedly express our acknowledgement to Prof. Dr. Prabir Kumar Manna, Principal of Seacom Engineering College, Howrah, West Bengal, India for providing the Laboratory for research work.

References

[1] G.A Deschamps, “Microstrip Microwave Antennas”, 3rd USAF Symposium on Antennas, 1953.

[2] J. R. James and P. S. Hall, Hand Book of Microstrip Antennas, Peter Peregrinus Ltd., London, United Kingdom, 1989.

[3] R. Garg, P. Bhartia, I. Bahl and A. Ittipiboon, Microstrip Antenna Design Handbook, Artech House, Boston, London, 2001.

[4] K. M. Lee and K. M. Luk, Microstrip Patch Antennas, Imperial College Press, London, 2011.

[5] I. J. Bahl and P. Bhartia, Microstrip Antennas, Artech House, Inc, Massachusetts, USA, 1980.

[6] S. Maity, “Approximate Solution for Fundamental Mode of 45°–45°– 90° Triangular Microstrip Antenna,” 4th IEEE Applied Electromagnetic Conference (AEMC) 2013, Bhubaneswar, India, 8-20 Dec,2013.

[7] Ansoft HFSS v 15.0 commercial simulation software.

[8] M. Lopez-Benitez, A. Umbert and F. Casadevall, "Evaluation of Spectrum Occupancy in Spain for Cognitive Radio Applications," *VTC Spring 2009 - IEEE 69th Vehicular Technology Conference*, Barcelona, 2009, pp.1-5.

[9] The European Table of frequency allocations and applications in the frequency range 8.3kHz to 3000 GHz (ECA table), published by Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administrations (CEPT), June2016. (http://www.erodocdb.dk/Docs/doc98/official/pdf/ercrep025.pdf, accessed on Sept 15,2017)

[10] S. Chaimool and K. L. Chung, "CPW-fed mirrored-L monopole antenna with distinct triple bands for WiFi and WiMAX applications," in *Electronics Letters*, vol. 45, no. 18, pp. 928-929, August 272009.

[11] E. Sidhu, V. Singh, H. Bhatia and P. Kuchroo, "Slotted rook shaped novel wide-band microstrip patch antenna for radar altimeter, IMT, WiMAX and C-band satellite downlink applications," *2016 International Conference on Global Trends in Signal Processing, Information Computing and Communication (ICGTSPICC)*, Jalgaon, India,2016, pp.334-337.

[12] Murari Shaw, Dipra Chakravorty, Saahil Islam, Malay Gangopadhyaya, “A simple Star shaped Microstrip Patch Antenna for penta band application,”2018 2nd International Conference on Electronics, Materials Engineering and Nano-Technology (IEMENTech), Kolkata, India