International Journal of Computer Information Systems and Industrial Management Applications.
ISSN 2150-7988 Volume 9 (2017) pp. 001-008

Nature Inspired Sunflower Shaped Microstrip Antenna for Wideband Performance

Pushpendra Singh[1], Kanad Ray [2*], Sanyog Rawat[3]
[1, 2, 3] Amity University Rajasthan

*corresponding author, [1] *singhpushpendra548@gmail.com*, [2] *kanadray00@gmail.com*, [3] *sanyog.rawat@gmail.com*

***Abstract*: This paper presents the design, analysis and synthesis of a high frequency nature-inspired broadband micro-strip patch antenna. It is based on the sunflower structure with particular type of the spirals which are frequently found in nature. The reason behind using sunflower structure is to explore whether we could replicate the properties of wideband performance, uniform and stable distribution of electromagnetic energy obtained in natural structure, successfully translated to antenna technology. The proposed antenna geometry has simple structure so it satisfies the requirements of satellite communication in form of the reduced lobe level and stable radiation pattern. The design is using Computer Simulation Technology Microwave Studio and the geometry of proposed antenna offers impedance bandwidth of more than 5.44 GHz (12 GHz to 17.44 GHz) in the Ku Band.**

***Keywords*:** Microstrip Antenna, sunflower spiral antenna, simulated result discussion, Parameter specification.

I. Introduction

Evolution has answered number of nature's challenges leading to long-term solutions. Through evolution various solutions have been tested and successful ones have been enhanced. Nature has always stimulated human achievements and has led to effective structures and processes. Nature's ability in many domains are much greater to human ones, and copying several features and distinctiveness can extensively improve our technology. This is so because a vast pool of inventions has gone through difficult tests of practicality and sturdiness in changing atmosphere. In order to bridge between these fields of biology and engineering one has to identify biological characteristics and look for equivalence in terms of engineering.

In present, modern wireless communication system, the antennas are the most important components required to create a communication link [1]-[4]. Antenna is a transducer design to transmit or receive electromagnetic waves [5]-[7]. An antenna is used to transform an RF signal, traveling on a conductor into an electromagnetic wave in free space. A high frequency planar antenna is more suitable for satellite communication. Various reconfigurable antenna have been reported in literature to achieve enhanced performance [8]-[10]. The study of a communication system is incomplete without understanding the antennas design and analysis. The microstrip antennas find application in aircraft also because they can be very handily flush mounted on the skin of the aircraft [11]-[13].The wireless communication system has led to increasing constrain on antenna utilized in terms of cost, size, bandwidth and many other antenna performance parameters. The state of the art antenna technology allows the use of different types and models of antennas, depending on the area of application considered [14]-[17]. Microstrip antenna provides a great revolution in the field of antenna design, research, many applications and advantages over conventional antennas [18]-[21]. But the major drawbacks associated with these antennas are narrow bandwidth and low gain [22]-[25]. In literature, several methods like stacked patches, defected ground, use of active devices have been investigated [26]-[30].

In this work, we are investigating a new method for building such antennas that could have several times improved radiation performance. The key intention of the present investigation is to provide a frame work for solving the optimization problems related to antenna application in satellite communication. A mathematical concept that is capable of defining many complex shapes found in nature is the key of this new design. Here, a new geometry of nature inspired antenna is proposed. A simple construction, broad bandwidth, adjustable and moderate gain are some of the key features of this design. Sunflower based micro strip patch antenna structure shows a non-uniformly spaced, direct radiating array which is responsible for reducing complexity and cost compared with conventional antenna. To the best of our knowledge the structure we have developed has not been explored before.

This paper is divided into 8 sections. The first section comprises of introduction. Particle swarm optimization algorithm is reported in section II. Inspiration description has been proposed in section III. Nature inspired antenna design is described in section III. Discussion of simulation result has been shown in section IV. Parametric analysis is presented in V. Section VI shows the deep discussion on simulation and theoretical results and conclusion is drawn in section VII.

II. Inspiration

The seeds in the sunflower are causable to capture the light in efficient manner, due to their orientation and distribution. The idea for this work started with the following hypothesis. If we put an antenna element with a fixed distance and fixed angle to increase them from the centre, after putting each point, it is connected to the nearest point among the points already put, such connection becomes spiral growing from the centre and their number is one of the fibonacci numbers as shown in figure 1. The arrangement has a good performance in capturing the electromagnetic wave. One of the mathematical patterns that can be found frequently in nature is the fibonacci sequence [13]. The angle, distribution of the seeds and spiral form are some example of these patterns. The Fibonacci sequence is defined as-

$$F = \{F_0, F_1, F_2, F_4\}$$

Such as

$$F_0 = 0$$
$$F_1 = 1$$
$$F_k = F_{k-1} + F_{k-2}$$

Figure 1. Fibonacci sequence found in the number of seeds in a sunflower [13].

III. Antenna Design and Analysis

Spiral elements are chosen in this antenna because they are easy to design and their shape is similar to a sunflower. The basic structure of the spiral is shown in fig. 2.

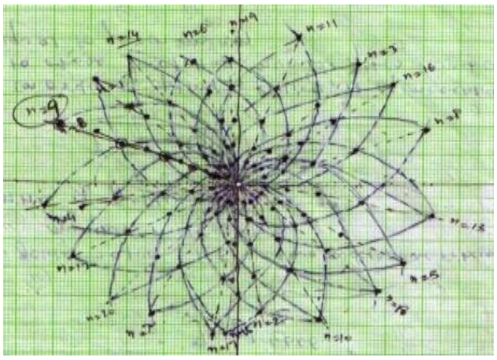


Figure 2. Basic structure of proposed design with spiral elements.

We calculate the position of the elements in proposed design by the following cartesian equation 1 to 4

$$Xn = Sn\sqrt{n/\pi}\ \cos\theta\cdot\beta \quad (1)$$
$$Yn = Sn\sqrt{n/\pi}\ \sin\theta\cdot\beta \quad (2)$$

Where n = 2, 3, 4……..

β = Phase control parameter

S (golden mean) = 1.695 (3)

$$Sn = Sn{-}1\sqrt{2} \quad (4)$$

The distribution of the antenna elements is achieved using a structure, which typically follows the pattern of the seeds in sunflower as shown in figure 3.

In many cases, the head of the flower is made up of small seeds which are produced at the centre, and then migrate towards the outside filling eventually all the space. Each new seed appears at a certain angle in relation to the proceeding one. In order to optimize the filling of the seeds, it is necessary to choose the most irrational number which is least well approximated by a fraction [14]. This number is called golden mean. The corresponding golden angle is 137.5 degree. With this angle, one can obtain the optimal filling spacing between the seeds as shown in fig. 3.

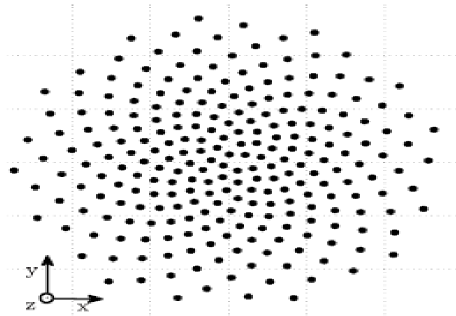


Figure 3. Seeds distribution in the sun flower [13].

A. *Golden ratio*

Golden ratio may be defined as

$$\epsilon = 1 + 1/\epsilon \quad (5)$$

After solving it $\epsilon = 1.618$ (6)

Fibonacci number series is

{2, 3, 5, 8, 13, 21, 34, 55, 89……………….}

If we take the two successive Fibonacci numbers [14]

P	Q	P/Q
2	3	1.5
3	5	1.666666666...
5	8	1.6
8	13	1.625
…	….	……………

B. *Golden Angle*

To choose the irrational part of the golden mean (0.695 approximately). The rotation is about 222.5° angle. In the other direction it is about **137.5°**, called the "Golden Angle. [14]

C. *Analysis of proposed design*

The length and the position of the spiral elements in the proposed antenna are obtained from eq. 1 and 2. For example the position of the 5 element can be calculated as follows:

Case 1: (β=1)

	(X_2, Y_2)	(θ= 137.5x1)
n=2	(0.068, -0.780)	137.5^0
n=3	(0.117,-1.344)	………..
n=4	(0.192,-2.20)	………..
n=5	(0.302,-3.47)	………..
n=6	(0.469, -4.70)	………..

Similarly we can obtain another coordinate of the points-

$$(\beta = 2, 3, 4, 5, 6 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots)$$

The maximum value of β is taken as 20 in order to maintain the design of the antenna simple.

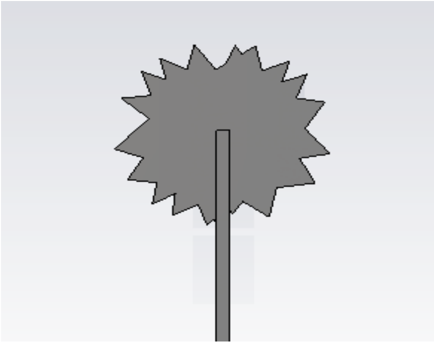


Figure 4. Front view of initial design.

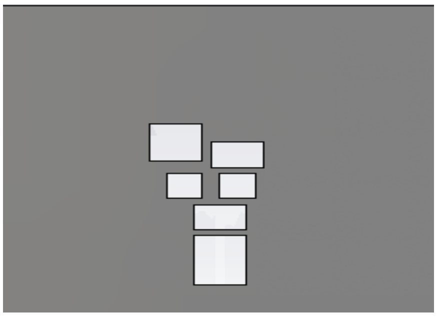
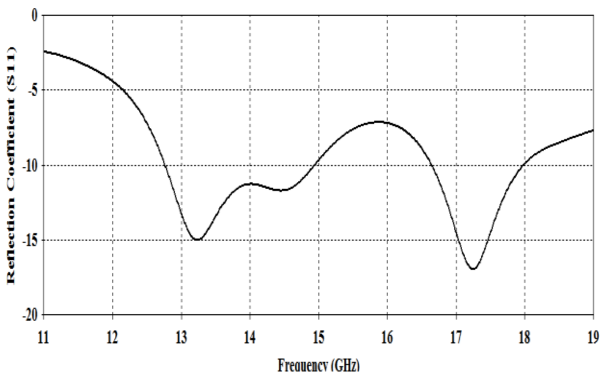


Figure 5. Rear view of proposed antenna.

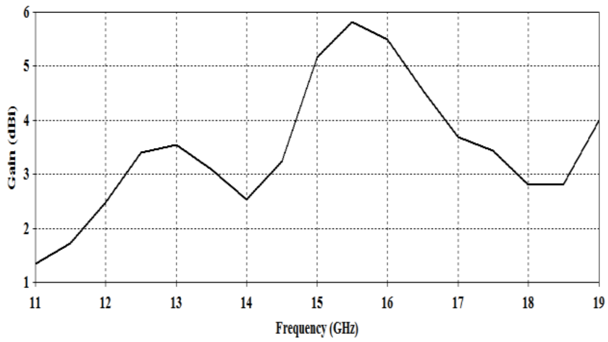
IV. Simulation Results

The initial design consists of glass epoxy FR-4 substrate (substrate relative permittivity $\varepsilon_r = 4.4$, substrate thickness h = 1.59mm, loss tangent tanδ = 0.025) and the size of the ground plane is considered as 30 × 30 mm, with micro strip line feed of dimension (15 x 1.2 mm) as shown in figure 4.

The variation of simulated reflection coefficient with frequency is shown in figure 6 (a). It clearly shows that the antenna is resonating at 13.1 GHz and 17.25 GHz and provides corresponding bandwidth of nearly 1.9 GHz and 1.3GHz in two bands. The variation of gain with respect to frequency is shown in figure 6(b) which indicates that at resonant frequencies i.e. 13.1 GHz and 17.25 GHz the gain is nearly 3.6 dBi and 4 dBi respectively.

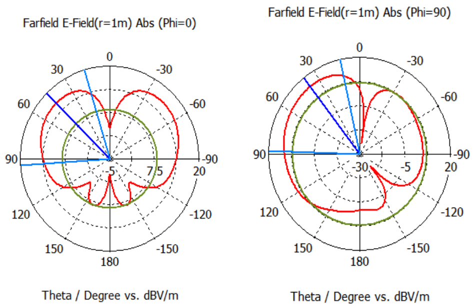


(a)

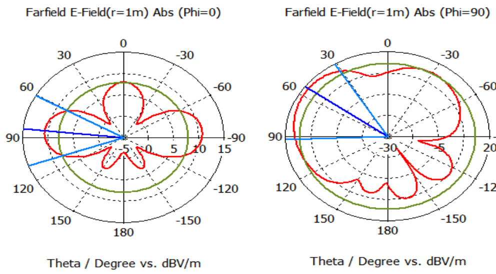


(b)

Figure 6. Variation of (a) reflection coefficient (dB), (b) Variation of gain (dBi) with frequency (GHz),



(a)



(b)

Figure 7. Variation of E and H plane elevation patterns at "(a)" 13.1 GHz, "(b)" 17.25 GHz.

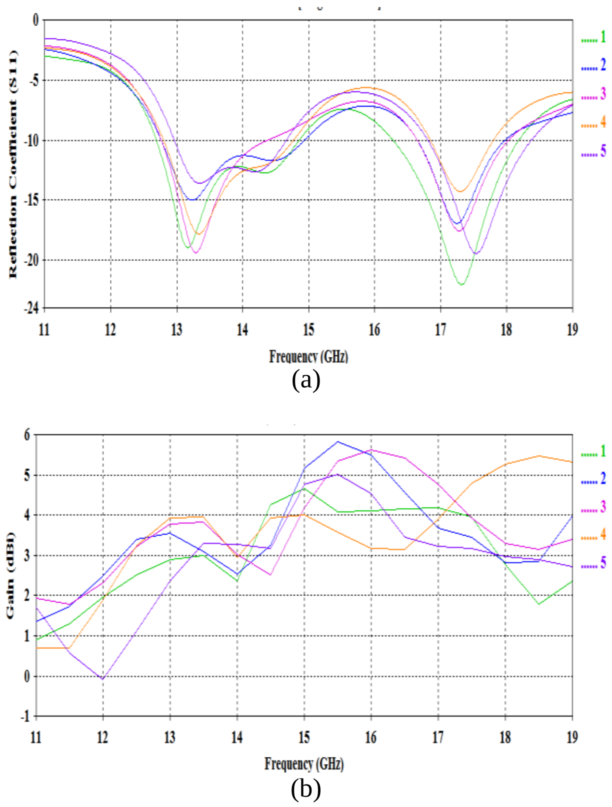
The elevation radiation patterns of initial design at resonant frequencies within the impedance bandwidth region are shown in figure 7. At first resonant frequency (13.1 GHz) the E and H pattern is tilted by 30^0 with radiation in the front direction only. The E pattern at second resonance frequency (17.25 GHz) is broadside in nature while H pattern radiation is tilted by 45^0 with more radiation in front direction. The results clearly indicate that this design in present form is not suitable for satellite applications.

V. Parameter Analysis for improved performance

The initial design is modified in steps in order to make this design suitable for Ku band of satellite communication application. The initial design is modified by taking the five different dimensional of the ground plane and the dimensions of patch are kept same as initial design. The results corresponding to the different ground size are shown in table 1.

Table 1. Five different configurations of ground plane dimensional with result.

Case No.	Ground plane dim. (mm)	R. fre. (GHz)	BW%	Variation of gain (dBi)
1	35x35	13.77 17.33	12.23 8.08	2.64-4.53 4.12-2.38
2	30x30	13.84 17.27	11.56 7.70	3.48-3.00 4.26-2.83
3	25x25	13.30 17.28	12.35 8.21	3.53-2.65 5.26-3.27
4	20x20	13.32 17.31	11.99 5.66	3.64-3.98 3.64-5.12
5	15x15	13.76 17.53	12.02 8.15	2.25-3.65 3.30-2.91



(a) (b)

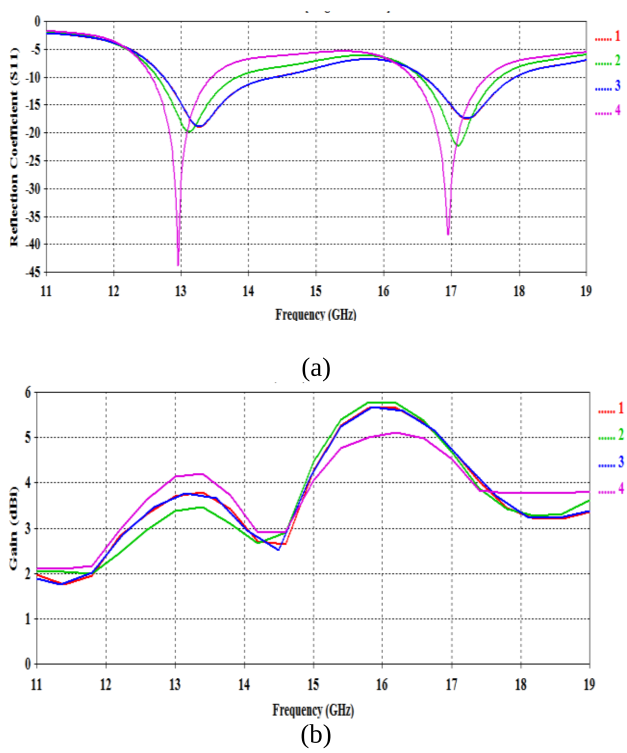
Figure 8. Variations of "(a)" Reflection Coefficient (S11), "(b)" Gain with frequency (GHz) for five considered configurations

As indicated in case-3, for ground size 25 mm × 25 mm, provide largest impedance bandwidth in both the bands (12.35%, 8.21%) as shown in figure 8 (a) it also gives nearly uniform gain of around 4 dBi across the entire bandwidth as shown in figure 8 (b).

The next parameter considered for analysis is the length and width of the feed line keeping ground size as 25 × 25 mm and similar dimensions for patch.

Table 2. Four different configurations of feed elements dimensional.

Case No.	Feed ele. dim. (mm)	Resonant freq. (GHz)	BW%	V. of gain(db)
1	13x1.2	13.30 17.28	12.32 8.21	3.53-2.65 5.26-3.27
2	13x0.8	13.09 17.01	8.86 7.05	4.19-3.84 5.44-3.57
3	13x0.6	13.27 17.28	13.66 8.20	3.47-2.54 5.30-3.40
4	13x0.4	12.97 16.90	6.89 6.33	3.62-4.14 5.09-3.85



(a) (b)

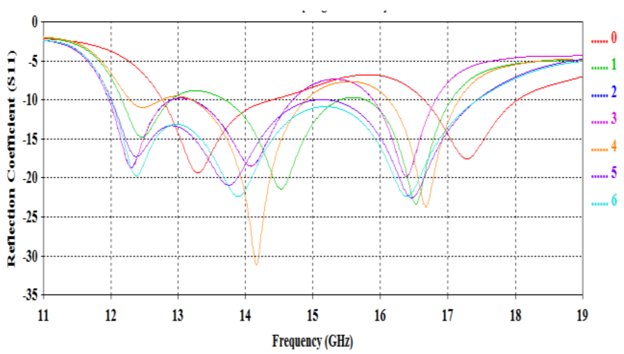
Figure 9. Variations of "(a)" reflection coefficient (S11), "(b)" gain with frequency (GHz) for four considered configurations of feed element

As indicated from figure 9. , the feed dimension 13 x 0.6 mm (case-3) provides improved bandwidth as compared to the design described in the preceding section. At resonating bands 13.27 GHz and 17.28 GHz, 13.66% and 8.20% bandwidth is achieved with uniform gain close to 4.5 dBi.

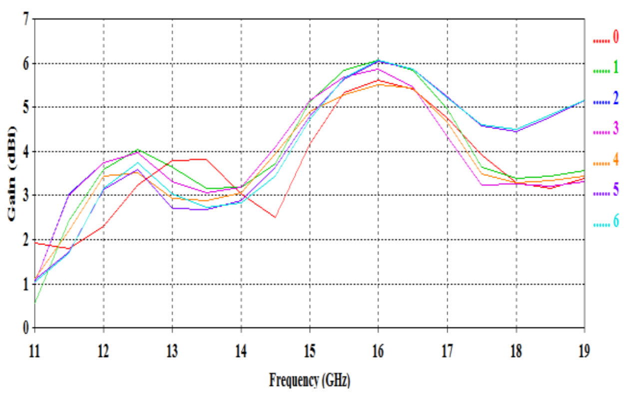
For attaining wideband performance the ground structure is modified by etching six slots, the dimensions of patch and ground are kept same as previous design. The results corresponding to the slots are shown in table 3 . The results show that as we increase the number of slots, the antenna impedance bandwidth has improved significantly. Till five slots the modified design was dual band but after insertion of sixth slot the antenna starts behaving as broadband and major improvement in bandwidth is depicted in figure 10.

Cutting slot No.	R. freq. (GHz)	BW%	V.of of gain (dBi)
0	13.27	13.26	3.47-2.54
	17.23	7.77	5.30-3.40
1	12.48	6.00	3.75-3.71
	14.54	11.72	3.17-5.68
	16.53	7.75	5.97-4.72
2	12.30	6.60	3.70-3.50
	14.11	10.41	3.19-4.15
	16.39	6.10	5.83-4.71
3	12.30	6.82	3.68-3.50
	14.08	10.65	3.22-4.56
	16.39	5.52	5.83-4.82
4	10.97	4.19	3.48-3.20
	14.16	12	2.91-4.72
	16.68	6.05	5.48-4.26
5	13	23.38	3.15-4.19
	16.46	13.06	5.25-4.66
6	12.38	38.58	3.16-4.56
		13.88	
		6.42	

Table 3. Six different configurations of slots in ground plane with results.



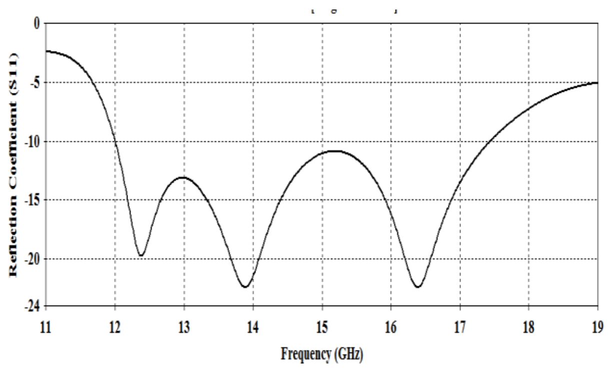
(a)



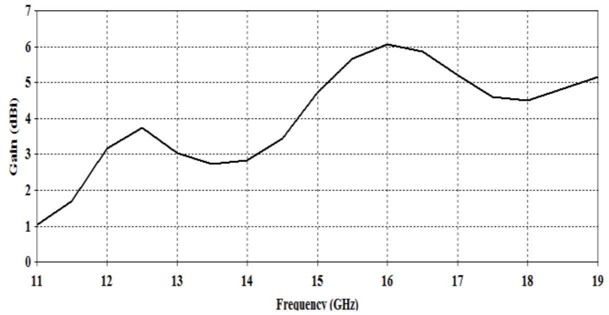
(b)

Figure 10. Variations of "(a)" Reflection Coefficient (S11), "(b)" Gain with frequency (GHz) for six considered configurations

The proposed design with 6 slots described in table 3 with ground plane size of 25 mm x 25 mm and feedline dimension of 13 x 0.6 mm provide best results. The variation of simulated reflection coefficient with frequency is shown in figure 11(a)., which shows that the antenna is now resonating at resonant frequencies of 12.38 GHz, 13.88 GHz and 16.42 GHz and has operating bandwidth of 5.44 GHz. The variation of gain of the antenna with respect to frequency is shown in figure 11(b). It may be seen that from frequency 12 to 15 GHz, i.e. in the frequency range having first two resonance frequencies, gain of antenna is nearly 3.15 dBi. Thereafter for a range of frequency, i.e. from 15 to 17.44 GHz, improvement in gain is realized and gain of antenna at the third resonance frequency of 16.42 GHz is close to 6 dBi.

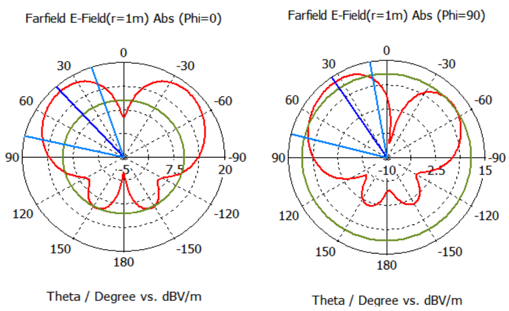


(a)

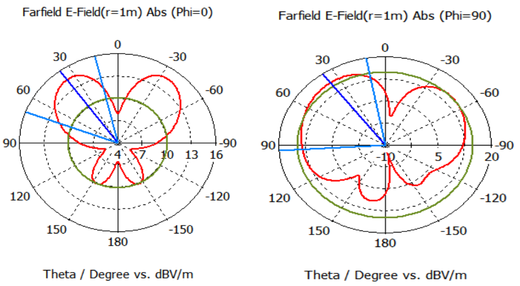


(b)

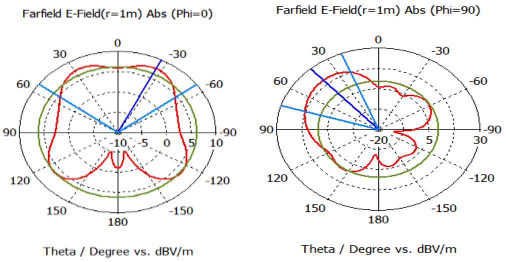
Figure 11. "(a)" Variations of (a) Reflection Coefficient (S_{11}), "(b)" Gain with frequency (GHz)



(a)



(b)

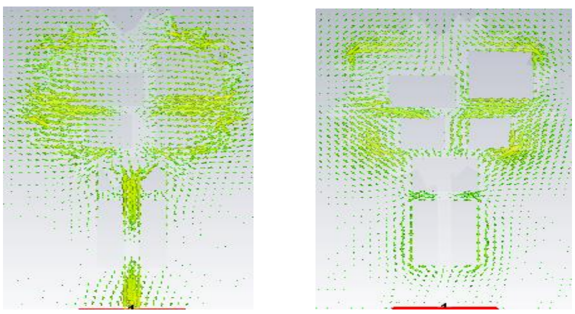


(c)

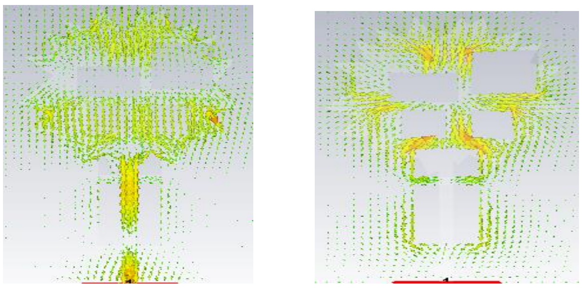
Figure 12. Variation of E and H plane elevation patterns at "(a)" 12.38 GHz, "(b)" 13.88 GHz, and "(c)" 16.42 GHz

The elevation radiation patterns of proposed antenna at three frequencies within the impedance bandwidth region are shown in figure 12. At first resonant frequency (12.38 GHz) the E and H pattern is tilted by 25^0 normal to the patch geometry and has most of the radiation in the front direction. The E and H pattern at second resonance frequency (13.88 GHz) are also tilted by 30^0 normal to the patch geometry. The E pattern at third resonant frequency (16.42 GHz) indicates that radiation is normal to the patch geometry and directive in nature whereas the H pattern is is tilted by 15^0 normal to the patch geometry.

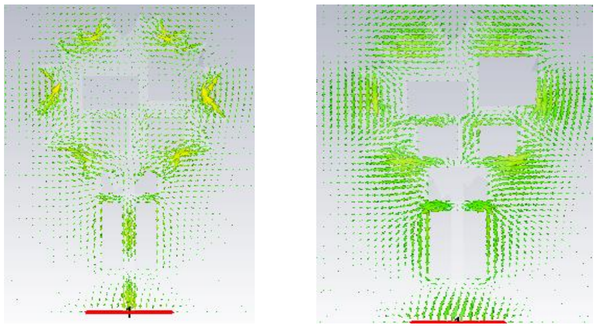
The current distribution on the element of the proposed antenna and on the ground plane is shown in figure 13. Figure 13(a) shows the surface current density distribution in the patch and ground at 12.38 GHz. The direction of the strong currents is towards the edges due to this strong resonance occurs at the first resonant frequency. Whereas at the second resonance frequency current densities at the patch and ground plane are opposite in direction which results in excitation of weaker mode as compared to the first shown in figure 13(b). The current distribution at the third frequency is also at the edges in the patch and the ground but the strength of current density is slightly more than the first resonance shown in figure 13(c).



(a)



(b)



(c)

Figure 13. Current distribution in patch and ground of the proposed antenna atresonant frequencies "(a)" 12.38., "(b)" 13.88, "(c)" 16.42 GHz

The radiation efficiency of proposed geometry is shown in figure 14. , which is close to 62% for the entire bandwidth except from 17 GHz to 17.44 GHz reduced efficiency is obtained. This compact size proposed antenna could be a better choice for Satellite communication applications.

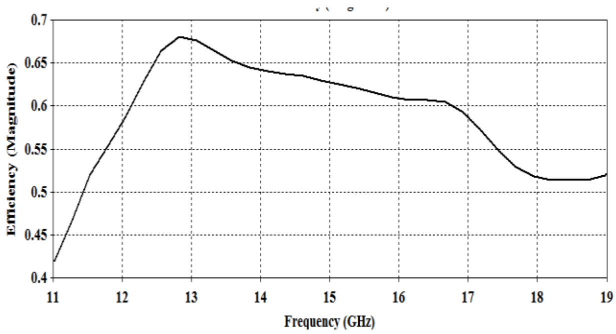


Figure 14. Variation of radiation efficiency with frequency for proposed antenna.

VI. Conclusion

A nature inspired design of low profile antenna with improved radiation characteristics is shown in this paper. The design is derived from sunflower structure with particular type of spirals which are frequently found in nature. By introducing defects in the ground plane structure and optimizing the feed and dimension of the ground the proposed geometry is resonating in the Ku band and provides an impedance bandwidth of 5.44 GHz with nearly uniform gain over the entire operating range. Detailed parametric analysis is also provided in this work to understand the underlying mechanism which could be important in designing antennas whose structures are borrowed from various symmetric features evolved over millions of years of time. This would pave a way to an important new line which will require collaboration between biologists and technologists along with the foundation of such an academic path that hopefully will also lead to new avenues of biometric science and engineering. The insight from nature is anticipated to continue leading to technology enhancement and the outcome is expected to be realized in every facet of our lives.

Reference

[1] C.A. Balanis. *Antenna Theory Analysis and Design*, John Wiley & Son, 2005.

[2] I. Singh, V.S. Tripathi. Microstrip Patch Antenna and its Application. *Int. J. comp. tech. appl.,* 2(5), pp.1595-1599, 2011.

[13] Y. Li, Z. Zhang, J. Zheng, Z. Feng, M.F. Iskander. A compact hepta–band loop- inverted F reconfigurable antenna for mobile phone. *IEEE Trans. Antennas Propag.,* 60(1) , pp. 389-392, 2012.

[4] J. Cho,W. Jung, and K. Kim.Frequency- reconfigurable two-port antenna for mobile phone operating over multiple service bands. *Electronic Letter*, 45, pp. 1009-1011, 2009.

[5] M. Puri, P.K. Mishra, S.S. Dhanik: Design and Simulation of Double Ridged Horn Antenna Operating for UWB Application. *Annual IEEE Conference, India*, 2013.

[6] M.K. Meshram, B.R. Vishvakarma, Gap-coupled microstrip array antenna for wide-band operation, *International Journal of Electronics*, 88, pp. 1161-1175, 2001.

[7] J.R. James, P.S. Hall. *Hand Book of microstrip antennas*, PeterP eregrinus Ltd, London, 1989.

[8]K. G. Jangid, V. S. Kulkar, V. Sharmat. Compact Circular Micro-strip Patch Antenna with Modified Ground Plane for Broadband Performance, *International Conference on Signal Propagation and Computer Tech,* pp. 25-28, 2014.

[9]P. Kumar, G. Singh: Advantage ComputationalTechnique in Electromagnetic, *4th International Conference on Communication System and Network Technologies, IJECS-IJENS*, 2012.

[10] I. Surjati, Y. KN. Increasing Bandwidth Dual Frequency Triangular Micro-strip antenna for Wi-Max application. *Internal Journal of Electrical & Computer Science,* 10 (06).

[11] S. Rawat, and K. K. Sharma. Stacked configuration of rectangular and hexagonal patches with shorting pin for circularly polarized wideband performance. *Central European Journal of Engineering., Springer,* 4, pp. 20-26, 2014.

[12] C. Vigano, M.: Sunflower array antenna for multi beam setallite application: *Laurea in Ingegneria delle Telecomunicazioni Universita di Ingegneria Firenze, Italia* , 2011.

[13] H. Vogel. A better way to construction the sunflower head. Mathematical Bioscience. , 44, pp. 179- 189, 1997.

[14] Y. Ramat- samii, J. M. Kovita, H. Rajagopalan: Nature-Inspired Optimization Technique in Communication Antenna Design. *Proceeding of the IEEE,* 100 (7), pp. 2132-2144, 2012.

[15] S. Rawat, and K.K. Sharma. Annular ring microstrip patch antenna with finite ground plane for ultra- wideband applications, *International Journal of Microwave and Wireless Technologies*, pp. 179-184, 2015.

[16] S. Rawat, and K.K. Sharma. A compact broadband microstrip patch antenna with defected ground structure for C-band applications, *Central European Journal of Engineering., Springer,* pp. 287-292, 2014.

[17] G.W. Ryan, J. L. Rouse, L. A. Bursill. Quantitative Analysis of Sunflower Seed Packing. *J. theor. Biol,* 147, pp. 303-328, 1991.

[18] V. Grob, E. Pfeifer, R. Rutishauser. Sympodial construction of Fibonacci-type leaf rosettes in Pinguicula moranensis (lentibulariaceae), *Annals of Botany*, 100(4), pp. 857- 863, 2007.

[19] J. A. V. Delgado, C.A.V Mera. A Bio- Insired Patch Antenna Array Using Fibonacci sequence in Oak- Tree*: published Research report*, USA, 2013.

[20] R. Takaki, Y. Ogiso, M. Hayashi, and, A. Katsu. *Simulation of sunflower spiral and Fibonacci numbers,* Tokyo institute of technology, Japan, 2003.

[21] S. Holm, A. Austeng, K. Iranpour, J.F. Hopperstad .*Sparse sampling in array processing in Sampling Theory*, F. Marvasti, Ed., Springer, New York, NY, USA, 2001.

[22] R. A. Dunlap: *The Golden Ratio and Fibonacci Numbers*, World Scientific, Singapore, 1997.

[23] S. Toshniwal, S. Sharma, . S. Rawat, P. Singh, and K. Ray, " Compact Design of Rectangular Patch Antenna with Symmetrical U slots on Partial Ground for UWB Applications**,"** Congress on (IBICA 2015).

[24] S. Rawat, and K. K. Sharma. Stacked elliptical patches for circularly polarized broadband performance, *International Conference on Signal Propagation and Computer Technology (ICSPCT 2014),* pp. 232-235, 2014.

[25] Y. Tawk, J. Costantine, C.G. Christodoulou. Cognitive –radio and antenna functionalities: A tutorial [Wireless Corner], *IEEE Antenna and Propagation magazine*, 56 (1) pp. 231-243, 2014.

[26] N. Nasimuddin, Z. N. Chen, X. Qing. Bandwidth Enhancement of a Single – Feed Circulary Polarized Antenna

Using a Metasurface: Metamaterial- based wideband CP rectangular microstrip antenna , *IEEE Antenna and Propagation magazine,* 58 (2) pp. 39- 46, 2016.

[27] S. X. Ta, I. Park, R. W. Ziolkowski. Crossed dipole antenna: A review. Mobile – Phone Antenna design, *IEEE Antenna and Propagation magazine,* 3 (3) pp. 177- 178, 2015.
[28] Y. P. Laxmi, M. U. Roa, B. S. Bahu. A Dual band Shaped Microstrip Patch Antenna for 2.4GHz and 5.4GHz Applications, *IEEE Antenna and Propagation magazine,* 54 (4) pp. 14- 34, 2016.

[29] B. P. Chacko, G. Augustin, T. A. Denidni. FPC Antenna : C- band point – to – point communication systems, *IEEE Antenna and Propagation magazine,* 58 (1) pp. 56- 64, 2016.

[30] H. Bayer, A. Krauss, T. Zaiczek, R. Stephan, O. E. Rosenblatt, M. A. Hein. Ka- Band User Terminal Antenna for Satellite Communications [Antenna Application Corner]Mobile – Phone Antenna design, *IEEE Antenna and Propagation magazine,* 54 (8) pp. 76-88, 2016.

Author Biographies

Pushpendra Singh was born in Kannauj, India in 1993. He received Bachelor of Science in Physics during 2009-12, and Master of Science in Electronic during 2012-14 from CSJM University Kanpur (UP) India. Presently, he is pursuing Ph.D. in the field of Bio and Nature inspired microstrip patch antenna from Amity University, Rajasthan.

Dr. Kanad Ray is presently working as Professor of Physics and Electronics & Communication (ECE) at Amity School of Engg. And Tech., Amity University Rajasthan. He is also the Head, Dept. of ECE. His research interest includes Cognitive Neurodynamics, Communication, Electromagnetic Fields , Antenna & Wave propagation, Microwave, Computational Biology and Applied Physics. He had obtained M.Sc in Physics from Calcutta University and PhD in Theoretical Nuclear and Astrophysics from Jadavpur University, India. He has several papers in National and International Journals of high repute. He has authored a book on EM Field Theory. He had served as one of the Editors of 'SocPros Proceedings' published by Springer Verlag, Germany in the form of 'Advanced Intelligent Systems and Computing ' series. He has acted as reviewer of various reputed journals e.g. 'Journal of Integrative Neuroscience' published by Imperial College Press; Sensing and Biosensing Research published by Elsevier etc. He had been appointed a Scientific Committee member of the 'International Conference on Vibration Problems' held at Lisbon, Portugal,Sept,2013. Also organized a Minisymposium on 'Neural Oscillation and Cognition'. Presently he has been guiding 8 Research Scholars for PhD. He has a few International Collaboration with members of Harvard Medical School,USA; Yale University, USA; University of Montreal, Canada; University Technology Malaysia and National Institute .of Materials Science, Japan.

Dr. Sanyog Rawat did Bachelor of Engineering in Electronics and Communication Engineering, Master of Technology in Microwave Engineering, and Ph.D in the field of Microstrip Patch Antenna from Malviya National Institute of Technology, India. Presently he is working as Assistant Professor at Amity School of Engineering and Technology, Amity University Rajasthan. He has several papers in National and International conferences and Journals. His research interest includes planar antennas, microwave devices and