# Design of Rectangular Slotted Spiral dual band antenna

Rajneesh kumar
*Department of Electronics Engineering*
*Madhav institute technology and science Gwalior India*
rajhinnoliya@gmail.com[1], bimalgarg@yahoo.com[2]

***Abstract*** **- Small size antennas are fabricated on the printed circuit board is generally utilized with communication application. In this paper a Rectangular spiral shape dual band antenna is proposed for mobile-satellite communication with a wide bandwidth. The first center frequency is 1.95 GHz with the bandwidth of 161MHz and second center frequency is 1.7 GHz with the bandwidth of 102 MHz. Radiation pattern of this Antenna shows a bidirectional pattern with the voltage standing wave ratio of less than two , return loss of less than -10 dB . Antenna parameters are taken out by the computer simulation tools microwave studio. The antenna is fabricated on Fr- 4 substrate with 4.3 dielectric constant and 1.6mm of thickness. It is observed that the simulated and measured values of the parameters of the antenna are quite close to each other.**

***Keywords*-Rectangular Spiral Antenna, CST Simulator, Microstrip**.

## I. INTRODUCTION

During the last couple of decades, there have been an enormous amount of papers on the design and applications of dual/multiband antennas[1]. Several studies have analyzed Rectangular spiral antenna structure as referred in[2]. It is used for land mobile or terrestrial- satellite network[3]. With time and requirements, these devices become smaller in size and also to be smaller and lightweight which results Microstrip antenna[4]. Small size antennas integrated on the circuit board is generally used in communication application[5]. Spiral antennas are directional antennas and circularly polarized with high gain and wide bandwidth [6]. The spiral antenna is class of frequency independent antenna under the angular concept[7]. This antenna form is based on the analysis of a spiral Monopole [8].
Spiral Antennas are usually circularly polarized and radiation pattern typically has a peak radiation and path vertical to the level surface of the spiral[9]. Spiral antennas are widely used in industry for sensing application, where wideband antennas that do not take up to a large extent gap are required. Numbers of turns of the spiral are varying According to the space between the arms. Practically it is found that spirals Exert fine with at least one half turn up to the three turns. Waves occur from the spiral antenna when the currents in the spirals section in the period. Since the spiral winds external from the center, there will be various area exist for each frequency where the currents append helpfully and generate radiation. The radiation removes the energy from the electric currents on the spiral antenna as a result the magnitude of current dies off with space from the spiral antenna[10]. The micro strip antenna makes them popular in many applications [11]. The antenna types being developed include printed Microstrip patch, planar slotted, multi-element monopole, Metamaterial-based monopoly etc[12]. The inner conductor of the probe extends through the dielectric at a point whereby the impedance and then soldered to the radiating patch [13]. The arms of a Rectangular spiral were generated by [14]. Furthermore, spiral antenna can avoid the use of different antenna for different services fig (1) since an excessive number of access points in one area can prevent the access due the interference with other access points [15].

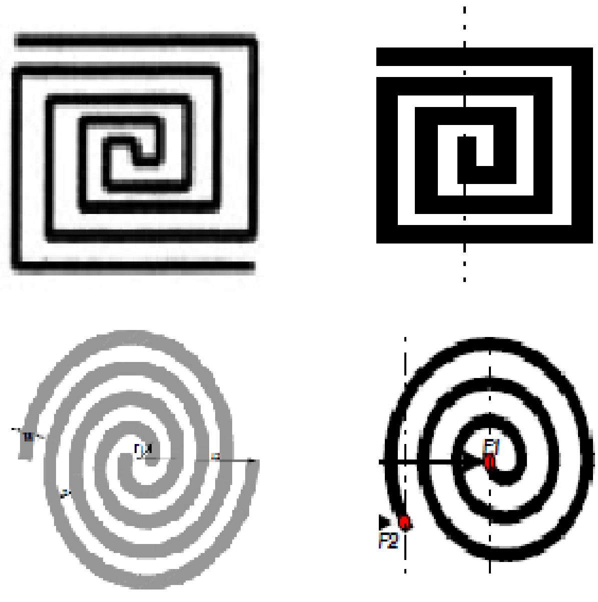

Fig.1 Variety of spiral antenna for broad band application

 

## II. METHODOLOGY

Dimension of the Rectangular Spiral dual band antenna and Properties of the substrate is explained in Table 1 and Table 2 respectively. Numbers of turns and space between terms is the most important.

| | |
|---|---|
| Number of turns | 3 |
| Width w (mm) | 3.79 |
| Inner radius (IR)(mm) | 4 |
| Space s (mm) | 3 |
| Height h (mm) | 0.038 |

TABLE I. ANTENNA DIMENSION

| Properties | fr-4 |
|---|---|
| Dielectric constant | 4.3 |
| Mue | 1 |
| EI. Tan | 0.098 |
| Thickness(mm) | 1.6 |
| Metal thickness(mm) | 0.038 |
| Resistivity | 1 |

TABLE II.PROPERTIES OF SUBSTRATE

### A. *Design Procedure*

The geometry of the slot is generated by dn = 2(n-1) d1, (n=2,3,...,10) where 2d1 (= ab) a denotes the length of the first turn of the single arm rectangular spiral slot respectively. It is assumed that the slot width, W is very narrowed compared with the wavelength at the resonance frequency $f_0$.

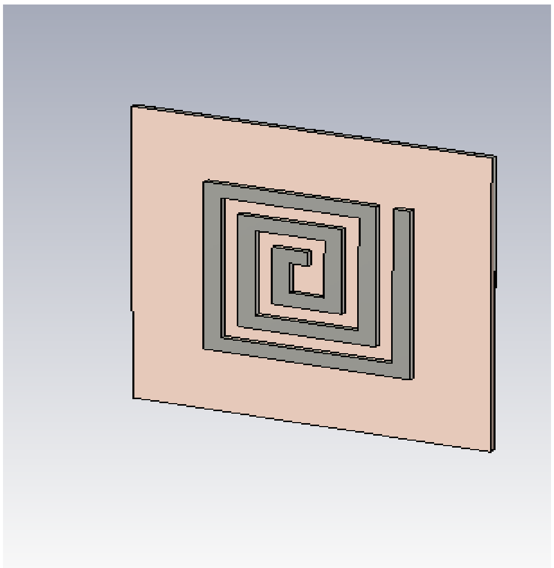

Fig.2 Rectangular Spiral Antenna

Fig (2) shows the Proposed Rectangular spiral shaped Dual band antenna consists of three turn and which is designed for 1.9GHz and 1.78 GHz on fr-4 substrate with 4.3 dielectric constant with 1.6mm thickness.

### B. *Feeder network*

Antenna feeder refers to a component of the antenna which supplies the Radio waves to the rest of the antenna configuration or in receiving antennas gather the incoming radio waves change them to electric currents and spread to collect. In simple antennas the feed usually consist of the supply antenna (focused element) the element of the antenna which actually changes the radio frequency currents to radio waves or vice versa and the feed line (conduction line) which connects the feed antenna. There are many methods that can be adopted to feed the antenna and can be classified into two categories; contacting and non-contacting. There are four most popular approaches are the microstrip line, coaxial probe, opening coupling and proximity coupling (both non- contacting schemes) line feed technique.
In this type of feed method, a conducting strip is connected directly to the edge of microstrip patch.

### C. *Effect of gap width on antenna*

It is found that the gap g of the turns of Rectangular spiral affects the antenna frequency response .Gap effect is not observed for the higher frequency band but it is observed for the lower frequency band .The dimensions of the fr-4 substrate is 60 mm x 60mm. The best width *W* for this antenna to perform as a mobile satellite communication antenna is 3.79 mm.

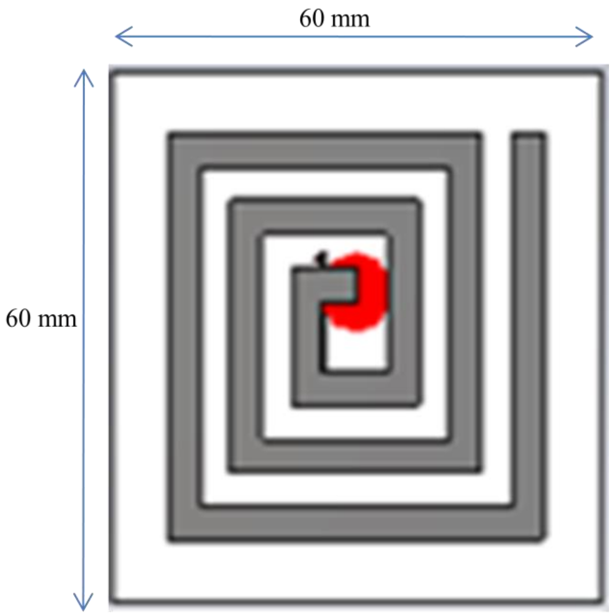


Fig.3 Simulated Spiral Antenna

Fig (3) shows the simulated three turn rectangular slotted spiral dual band antenna. Here CST Microwave Studio is used to obtain the Return loss, the radiation patterns and other needed parameters.

 

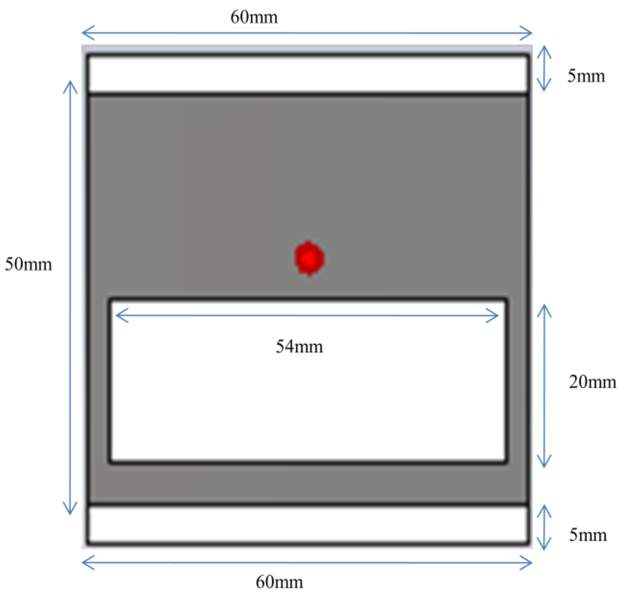


Fig.4 Back View of Antenna

Fig.(4)explains the dimension of the ground plane and having the dimensions of 50mmx60 mm. Metal thickness of the ground plane 0.038mm.There are three cuts in the ground plane first cut having the dimension of (54mmx20mm), second and third cut having the similar dimension of (5mmx60mm) . Radiation Efficiency depends mostly on the first cut.

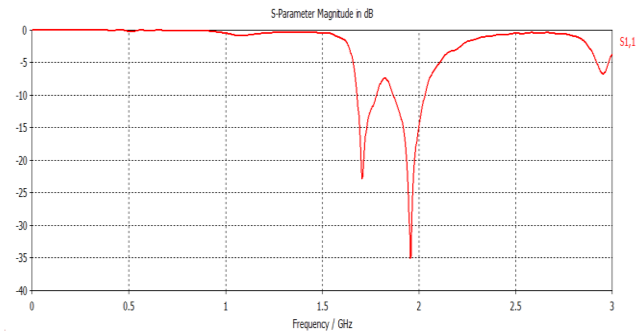


Fig.5 Return Loss at 1.95 GHz and at 1.7 GHz

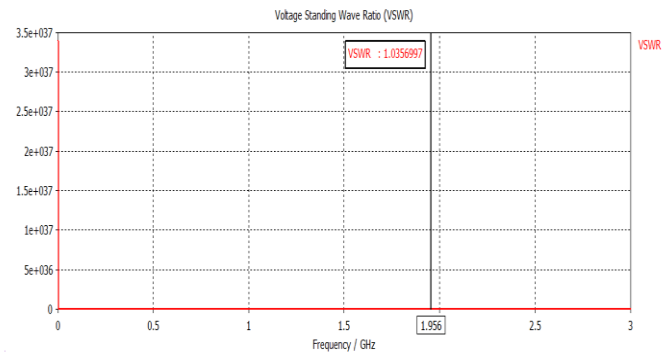


Fig.6 VSWR is 1.03 at 1.95 GHz

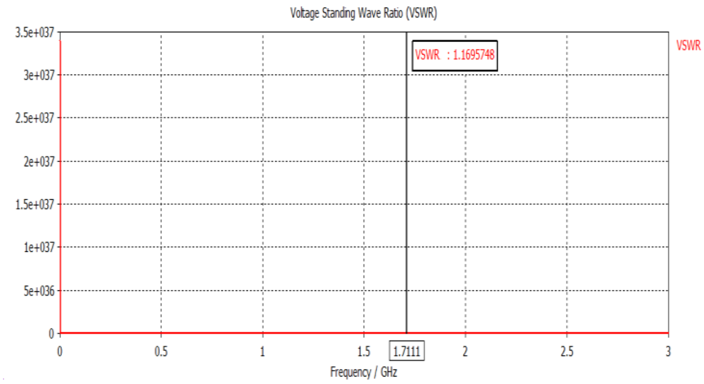


Fig.7 VSWR is 1.05 at 1.7 GHz

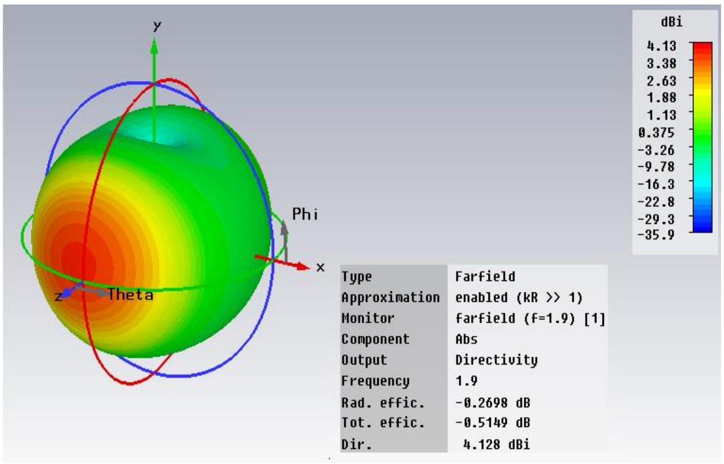


Fig.8 3D Radiation Pattern at 1.95 GHz

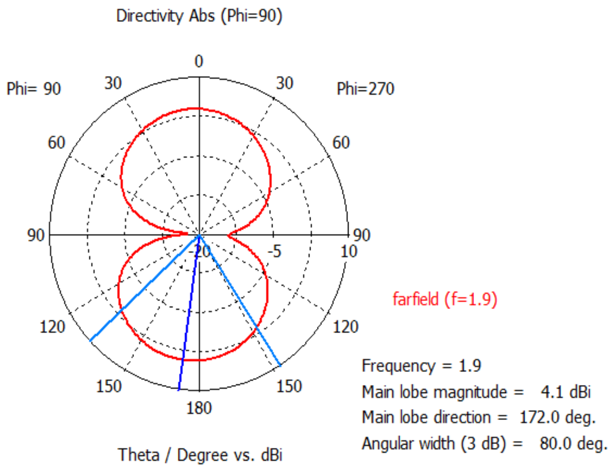


Fig.9 Radiation Pattern in polar form at 1.95GHz

Fig.(5) shows the Return loss $S_{11}$ of the both frequency bands by the simulation which are -35.12db at 1.95GHz and 22.16db at 1.7 GHz. Fig (6)(7) shows the Voltage standing wave ratio of the both centre frequency. Fig (8)(9) shows the 3D radiation pattern and the radiation pattern in polar form.

 

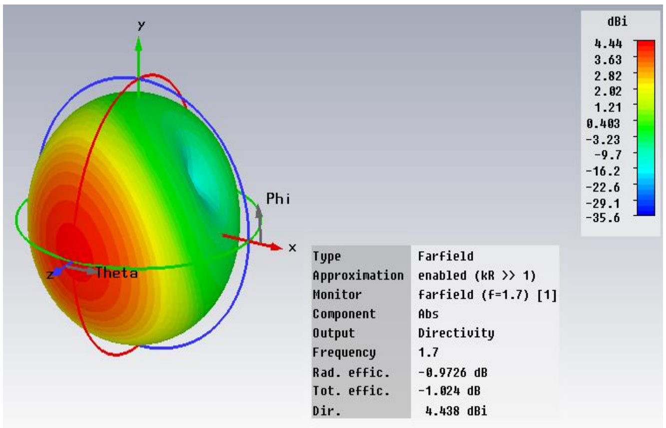


Fig.10 3D Radiation Pattern at 1.7 GHz

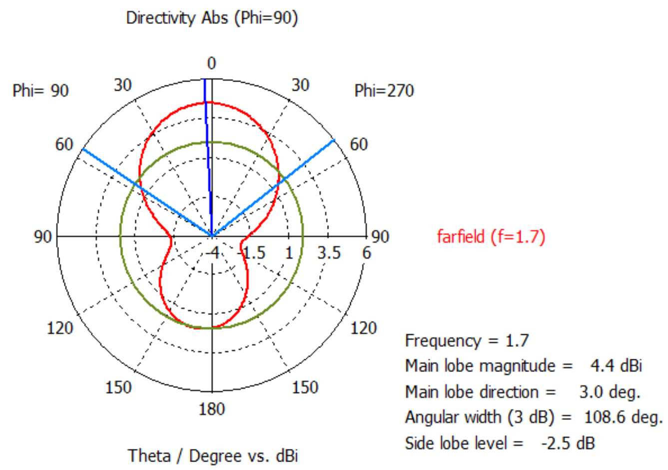


Fig.11 Radiation Pattern in polar form at 1.7GHz

Fig (10) shows the 3D radiation pattern at the frequency 1.7GHz Fig (11) shows the Radiation pattern in polar form . Two different polarizations are radiating, right - hand circular polarization in one direction and left-hand circular polarization in the opposite direction. Approximately perfect circular polarization is achieved at the position $\theta = 0^0$ and Main lobe magnitude is 4.4 dBi and the direction is 3.0 deg. Hence most part of the power is radiated with a circular polarization.

The antenna fulfils the required values of parameters to act as a mobile satellite antenna communication. It can be used for many other applications, then fabrication of the prototype rectangular spiral dual band antenna is carried out prior to analysis and measurement.

## III. RESULTS AND DISCUSSIONS

The fabrication of the antenna has been achieved in fr-4 lossy substrate with $\varepsilon_r = 4.3$ and $h = 1.6$ mm. The prototype of the antenna is shown in Figure (2) with the dimensions of $W$ =3.79, S = 3 mm and inner radius= 4 mm. Measurements of the return loss, voltage standing wave ratio is carried out By using a transient solver And calibration procedure is used prior to the measurement. Analysis of the simulated values of Return loss $S_{11}$, the voltage standing wave ratio, and the radiation pattern is illustrated by Figures (5),(6),(7) and (8),(9),(10),(11) respectively. All the values are obtained met the specifications. The value of the return loss $S_{11}$ is -35.12 dB at 1.95 GHz. this value is very good since it is lower than -10 db and the measured value is -34.09db at 1.94GHz it shows close agreement between measured and simulated values. The Simulated value of the voltage standing wave ratio is 1.03 and the measured value of the voltage standing wave ratio is 1.12 at 1.94GHz, while the ideal value of the voltage standing wave ratio is unity. The low value of the voltage standing wave ratio is indicated that the antenna has a low value of reflected power at $f_c$=1.95GHz. The simulated value of return loss is -22.16 db at 1.70GHz and the measured value of the return loss is -22db at 1.71GHz . Simulated value of the voltage standing wave ratio is 1.05 at $f_c$ = 1.70 GHz. and the measured value of the voltage standing wave ratio is 1.16 at 1.71GHz it is also close to unity .The bandwidths of 1.95 GHz and 1.7GHz are 161MHz, 102MHz respectively .The use of coaxial feeding techniques caused the input impedance to be inductive and vary slightly in values from the simulated value. However, the values are quite close to each other. The radiation pattern of the antenna is bi-directional as depicted by Fig.(9) and Fig. (11)Which are obeying the requirement of space to earth communication .The discrepancies might be due to the parasitic losses and the value of fr-4 dielectric constant that is used during the fabrication process. The fr-4 dielectric constant may vary from 4.3 to 4.6. Specialty of this antenna is both voltages standing wave ratio is very close to 1. Simulated and Measured parameter of the prototype rectangular spiral dual band antenna is summarized below in Table 3 and Table 4.

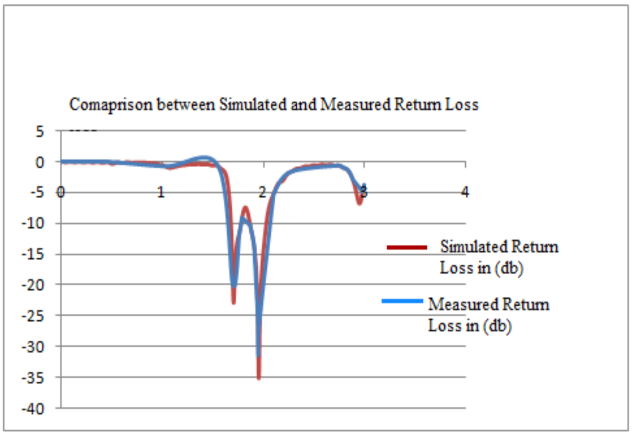


Fig.12 Comparison between Simulated and Measured Values of $S_{11}$

The measured and simulated Return loss values are compared as illustrated by Fig (12).There are slight discrepancies between the simulated and measured values of the parameters of the rectangular spiral dual band antenna. The discrepancy of dimension during fabrication also contributed factors that caused the errors are the effects of connectors, soldering patch and air gap that introduced to the error. Hardware view is in fig (13).

| Parameter | Simulated | Measured |
|---|---|---|
| $f_c$ | 1.95 GHz | 1.94GHz |
| $S_{11}$ | -35.12db | -34.09db |
| VSWR | 1.03 | 1.12 |
| Radiation pattern | Bidirectional | Bidirectional |

TABLE III .RESULT COMPARISON AT 1.9 GHz

| Parameter | Simulated | Measured |
|---|---|---|
| $F_c$ | 1.7 GHz | 1.71 GHz |
| $S_{11}$ | -22.16 db | -22db |
| VSWR | 1.05 | 1.16 |
| Radiation pattern | Bidirectional | Bidirectional |

TABLE IV.RESULT COMPARISON AT 1.7 GHz

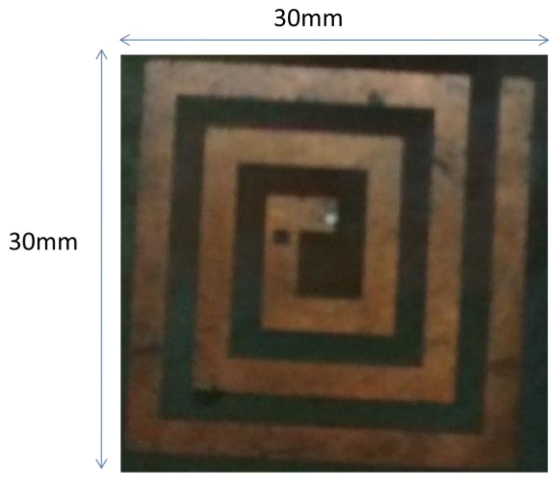


Fig .13 View of Hardware

## IV. CONCLUSION

According to the simulating and measure results, the characteristics of rectangular spiral dual band antenna have both results are very close to each other and voltage standing wave ratio very close to ideal values and return loss in one band is also high . Rectangular spiral dual band antenna has wide bandwidth with bidirectional pattern and approximately perfect circular polarization max radiated power at θ = 0 .Voltage standing wave ratio of the both frequency very are close to 1.

## *References*


[1] A.S. Andrenko, "*Planar dual–Band Spiral monopole Antenna,*" Antennas and Propagation in wireless communication (APWCC), IEEE-APS Conference Torino, pp. 562-565, September 2011.

[2] Pavita Wiriyacosol, Noppin Anantrasirichai ,pitakthumwarin and Toshio Wakabayashi , "*Tri Band Rectangular spiral slot Antenna with L-shaped slot Antenna for WLAN and Radar Applications,*" SICE-ICASE Joint International Conference Busan Korea, pp.1408-1411,Oct. 2006.

[3] K. khalil, R.A. Abd. Alhameed, and P.S. Excell, "*Dual Band Quadrifilar Rectangular spiral antenna for mobile satallite handsets,*" Antennas and Propagation (ICAP2003) Exeter UK,Vol. 1, 31 March, pp.186-189, 2003.

[4] Aiza Mahyuni Mozi, Dayang Suhaida Awang Damit, Zafirah Faiza, "*Rectangular Spiral Microstip Antenna for WLAN Application,*" IEEE Control and System Graduate Research Colloquium (ICSGRC2012) Shah Alam Selangor, pp. 181-185, 2012.

[5] Ria Maria George , Suresh Nair, Amhad P.Ameen, Dinesh kumar, "*Integraded Spiral –Shaped Monopole Antenna for 2.4/5.2GHz Dual- band Operation,*" IEEE International Conference on Microelectronics ,Communication and Renewable (ICMiCR-2013) Kanjirapaly, pp. 1-5 , 2013 .

[6] Xiang Liu, Junping Geng, Xianling Liang, Ronghong Jin, Cheng Zhang, and Kun Wang , "*An Improvement to Directional Equiangular Spiral Antenna with Wide CP Band, High Gain and Low Profile,"* Progress In Electromagnetics Research C, Vol. 48, pp. 53-60, 2014.

[7] C.A. Balani "Antenna theory," 2nd ed. John Willy &Sons Inc.1997.

[8] Dinisio Raony Riberio, Leonardo Augusto de Santana ,Marlin Carnerio Alves and Jose Felip Almedia ,Carlos Leonidas da S.S Sobrinho, "*Spiral Microstrip Antenna,*" IEEE MTS-S International Microwave and Optoelectronics Conference (IMOC 2007), pp. 104-106, 2007.

[9] Zhu Li,Wang, Guang–Ming, Gao Xiang-jun, Liang, "*Design of a New spiral Circular Polarization Broadband Microstrip Antenna*," Journal of Microwaves in china, Vol. 24, pp. 21-24 ,2008.

[10] www.antennatheory.com/antennas/travelling/spiral.php.

[11] Md.Tanvir Ishtaique-ul huque, Md. Shihabul Islam, Mst. Fateha, "*Design and Performance Analysis of the Rectangular Spiral microstrip antenna and its array configuration,*" antenna propagation and EM theory(ISAPE) 9th International symposium Guanghou, pp.219-221, 2010 .

[12] J.Zhu and G.V. Eleftheriades, "*Dual-Band Metamaterial-Inspired Small Monopole Antenna for Wi Fi Application,*" IET Electron Lett, Vol.45, no. 22 Oct. 2009.

[13] M.F. Mohd Yusop, K.ismail, S. Sulaiman and M.A. Haron "*Coaxial feed Archimedean Spiral Antenna for GPS Application,"* Proceeding of 2010 IEEE Asia- pacific Conference on Applied Electromagnetics (APACE) pp.1-5, Nov. 2010.


 

[14] S. Shi, K. Hirasawa, and Z. N. Chen, "*A dual – band cavity – backed single arm square spiral slot antenna,*" Proceeding of ICCEA, pp.191-194, 1999 .

[15] M.F. Abdul Khalid, M.A. Haron, Baharuddin , and A. A. Sulaiman, "*Design of a spiral antenna for Wi-Fi application,"* IEEE Inter. RF and Microwave Conf. Proc. KualaLumpur, pp. 428-432, Dec. 2008.