**International Journal of Engineering Research and Development**
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 14, Issue 01(January 2018), PP.44-50

# Investigation of Circularly Polarized Fractal Antenna At 2.1ghz For LTE Application

*S.B.Kumar [1], P.K. Singhal [2]
*[1] Dept. of Electronics & Communication, Bharati Vidyapeeth's college of Engineering, New Delhi, India*
*[2] Dept. of Electronics, Madhav Institute of Technology & Science, Gwalior, India*
*Corresponding Author: S.B.Kumar*

**ABSTRACT.** In this paper a circularly polarized (CP) microstrip antennas with fractal boundary are presented. The proposed antennas are designed by cutting diagonally symmetric rectangular slot & truncating opposite corners to get circular polarization. The indentation factor is optimized to have good result at 2.1GHz for Long term evolution(LTE) downlink application. The simulated and measured results are in good agreements. The axial ratio is about 1.72dB.The presented antenna has advantage over physical size
$0.25\lambda0\times0.25\lambda_0\times0.012\lambda_0$.The
**Keywords:** overall performance of parameters of presented antenna is very good. Fractal boundary, long term evolution, Indentation factor, Indentation radius

---

Date of Submission: 29-12-2017 Date of acceptance:12-01-2018

---

## I. INTRODUCTION

In advance wireless communication system, there is a requirement of high data rate as well as security of the data. This increases the demand of LTE communication. Now a days LTE is in a great demands to resolve the issues of fourth generation (4G). Polarization of an EM wave has an important role in the transmission of the wave .In this paper circularly polarized antennas for LTE communication system are proposed. In the current scenario most of the 4G mobile phone requires LTE antenna which support LTE Band. This antenna has frequency band 2.1GHz LTE Downlink communication. Wireless devices for LTE communication operating range from 400MHz to 4GHz & bandwidth allocated for this range is 1.4 to 20MHz [1].Looking towards the advancement of LTE communication some antenna design was proposed in [2],a dual band behavior antenna is introduced at 700MHz and 2600MHz.A triangular shape 1st iterated antenna is proposed. There is good impedance matching as well as size reduction with respect to original size. A fractal boundary circularized antenna is introduced for WLAN Communication. To have good CP a poly fractal slot inclined at $45^0$ is introduced at the center [3]. A meander line antenna for LTE at 700MHz is presented for cellular phone band used in United States[4]. A dual- polarized antenna for dual band in the range 1.7-2.1GHz have been suggested [5] . Maximum gain has been shown in given range is 3.84dBi.Some fractal boundary design has been proposed [6].Circularly polarized antenna is discussed with fractal boundary. A Sierpinski Fractal Antenna has been proposed at 800MHz for LTE Devices. Microstrip feed antenna has good impedance matching & better radiation .Multiple input and multiple output (MIMO)technique that can be used very effectively for the advancement of upcoming generation of wireless communication like LTE & 4th generation[7].Microstrip fractal antenna for logistic management has been introduced [8].

Multiband fractal antenna for different application using symmetrical slot has been designed to get desired result [9–14]. There are many technique used to design fractal antenna [13–20] keeping the view of self symmetry, has been proposed and has better optimization. In this proposed antenna, keeping in the view to have better improvement in overall parameter so that proposed antenna can suit into many applications. Presented antennas have advantages of small size, better gain and large beam width at frequency 2.1GHz for LTE application. Compare[5–6] proposed antenna has better gain of 4.9dBi and small in size $0.25\lambda_0\times0.25\lambda_0 \times 0.012\lambda_0$ .Using IE3D antenna simulator ,proposed antenna has been designed & simulated. Fabrication has been done using FR4 material. using network analyzer .There is a good agreement between simulated and measured result.

**1.1 Antenna Design and Analysis**

A poly fractal boundary antenna is proposed and symbolic geometry representation of 2nd iteration antenna is shown in fig 1. Characteristics of the fractal curves depends on the two parameters indentation factor(IF) and indentation radius (IRs)[3].In the proposed design, the indentation factor (IF) and indentation radius (IR) are same. Indentation radius $r_x$ and $r_y$ are IRs along the x-axes and y-axes. The proposed antennas are square patch with fractal curves on all the sides of the patch. Fractal curves are half circled with different indentation radius IRs. The description of the parameters is given in design parameters.

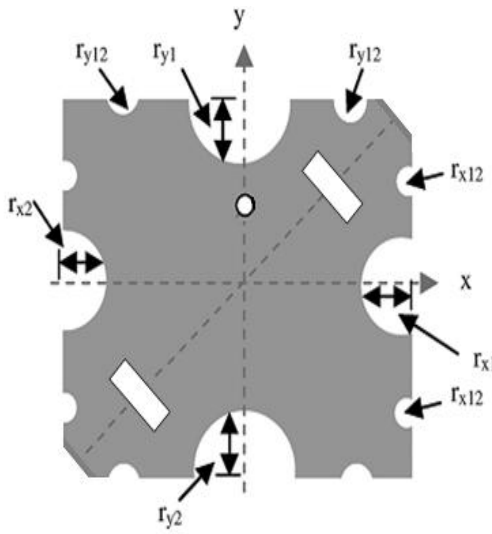


**Fig1**. Asymmetrical fractal boundary patch

1. Specifications of the proposed antenna are as follows:
2. Design Frequency: 2.27GHz
3. Substrate Thickness: 1.59mm
4. Substrate Dielectric constant (FR4): 4.4
5. Patch Dimension: 33mm × 33mm
6. Rectangular slot dimensions: 6mm × 2mm (inclined at $135^0$)
7. Loss tangent: 0.02
8. Dimensions of truncated corners: 3.2mm × 3.2mm
9. Probe feed coordinates: (0, 6)

To get good impedance matching, feed point is optimized and keeping coaxial feed radius is 0.5mm.Antenna design parameters are optimized to have good reduction in size ,lowest axial ratio and maximum gain. The proposed antenna geometries are mention in Fig 2.

**1.3 Asymmetrical fractal boundary proposed antenna and Result Analysis**

Poly fractal boundary antennas are shown in Fig2.The Proposed antenna is square antenna with truncated corner. It‘s size is 33mm × 33mm & has 3.2mm × 3.2mm truncated corner on diagonal axis. To keep good impedance matching, feed point is chosen on vertical axis at (0,06).There are six antenna presented in this paper as shown in Fig2.Fractal boundary of this antennas are of different indentation radius as shown in Tab.1.Ant1 is of (Iteration order)$IO_1$ has indentation radius $r_{x1}= r_{x2}= r_{y1}=r_{y2}$ resonating at 2.1GHz.Ant1 is a symmetry microstrip patch antenna as all IRs are same. From the Tab.2, ant1 has good gain, minimum axial ratio and large beam width when IRs $r_{x1}=r_{x2} = r_{y1}=r_{y2}$. Maximum axial Band width is seen when $r_{x1}=r_{x2} \neq r_{y1}=r_{y2}$ which is of Ant2.All six antenna are circularly polarized antenna. This is because truncation of the opposite corners, slot embedded on diagonal axis with inclination of $135^0$ and optimization of IRs.It is seen from Tab.2, when $r_{x1} \neq r_{x2}$ & $r_{y1} \neq r_{y2}$ minimum axial Band width is achieved which is for Ant4.For the $IO_2$ Ant5 overall parameter achieved are quite good with IRs $r_{x1} \neq r_{x12}$ , $r_{y1} \neq r_{y12}$.Ant6 is achieved small range of axial frequencies but reasonable value of other parameters. All Simulated graph with compared result has been shown in given fig.3-6.

## II. MEASURED RESULT ANALYSIS

Most suitable simulated results among proposed antenna are mentioned in Tab.2. Ant2 is fabricated with specification mentioned in this paper. To validate the simulated result of proposed antenna, fabricated antenna as shown in figure7-8 & is tested using network analyzer & measured results are shown in figure 9-10.Tested result and simulated result are compared with center frequency 2.1GHz.There is a good agreement between simulated and measured result. From tested result of S-parameter, it is seen that minimum value of $S_{11}$ is 20dB while simulated result has $S_{11}$ is 30dB .There is a deviation in $S_{11}$ value, this is because of tolerance level in feeding process manually while fabricating. Due to mismatching impedance there is loss of feeding power. But overall performance of fabricated antenna is quite good as results are very much comparable with measured result.

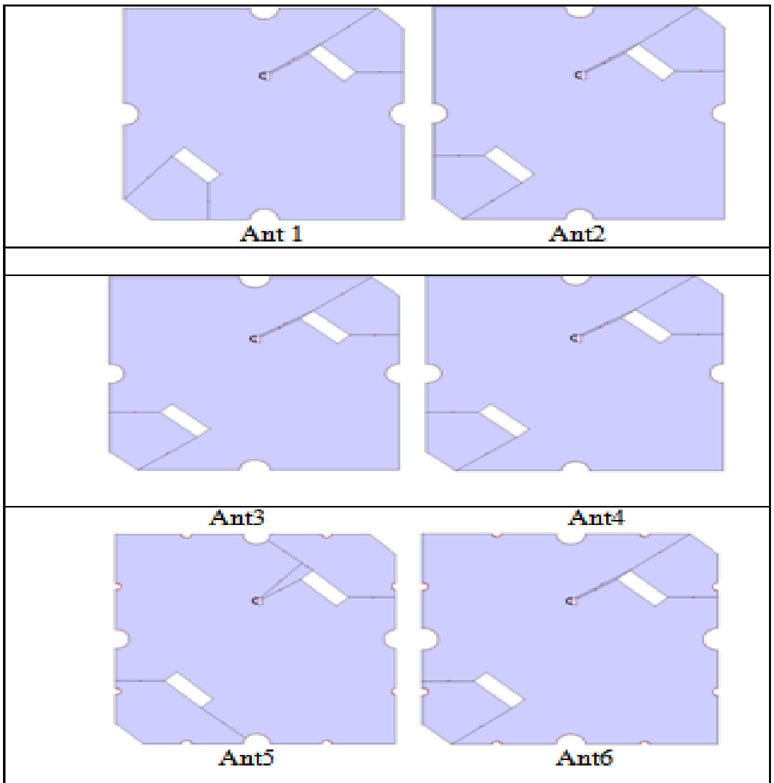


**Fig 2.** Proposed antenna geometries

**Tab.1.** Indentation Radius of proposed antenna

| Antennna | Indentation Radius IRs $[r_{x1}, r_{x2}]/[r_{x1}, r_{x2}]$ or $[r_{x1}/r_{x12}],[r_{y1}/r_{y12}]$ |
|---|---|
| Ant1 | 1.7 |
| Ant2 | 1.5/1.6 |
| Ant3 | 1.65/1.75 |
| Ant4 | (1.585,1.6)/(1.565,1.57) |
| Ant5 | (1.5/0.5),(1.6/0.6) |
| Ant6 | (1.75/0.6),(1.65/0.5) |

| Antenna | S11 band Width [MHz] | Axial bandwidth [MHz] | Max field gain [dBi] | Beam width [degree] | Max Antenna efficiency [%] |
|---|---|---|---|---|---|
| Ant1 | 40.88 | 6.82 | 4.90 | 110.36 | 72.306 |
| Ant 2 | 42.05 | 8.62 | 4.90 | 107.32 | 72.407 |
| Ant 3 | 40.87 | 7.45 | 4.88 | 106.77 | 72.024 |
| Ant 4 | 41.87 | 4.47 | 4.90 | 105.78 | 72.325 |
| Ant 5 | 41.11 | 7.81 | 4.9 | 109.17 | 72.320 |
| Ant 6 | 40.02 | 5.02 | 4.8 | 105.82 | 70.570 |

**Tab.2.** Summarized result of all parameters

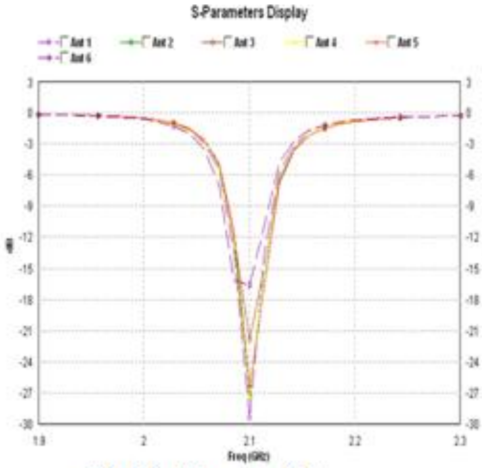


Fig.3. $S_{11}$ Parameter Plot

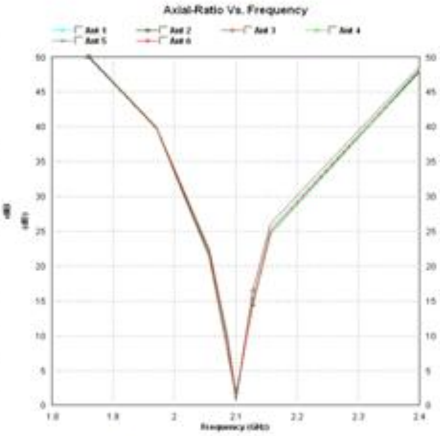


Fig.4. Axial Ratio plot

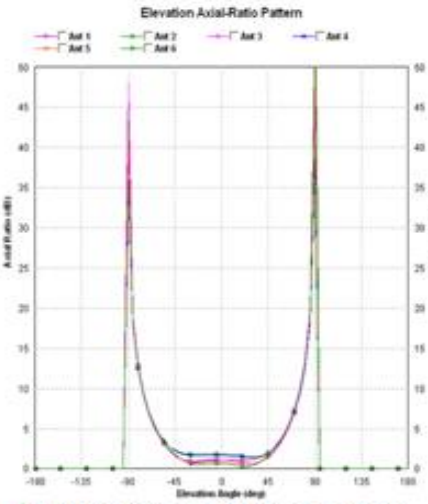


Fig.5. Axial Ratio vs. Elevation angle plot

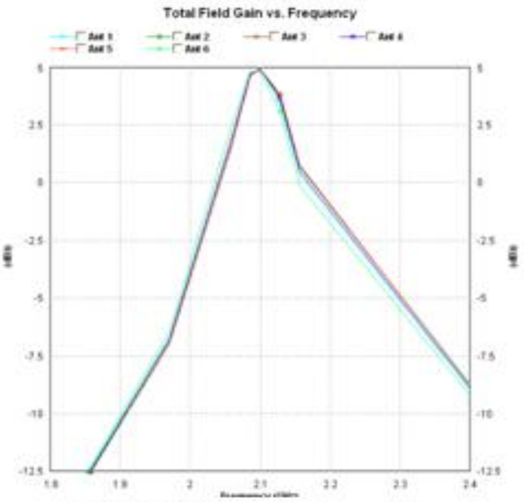


Fig.6. Field Gain vs. Frequency Plot

Fig.7. Top view of fabricated Ant2

Fig.8. Bottom view of Fabricated Ant2

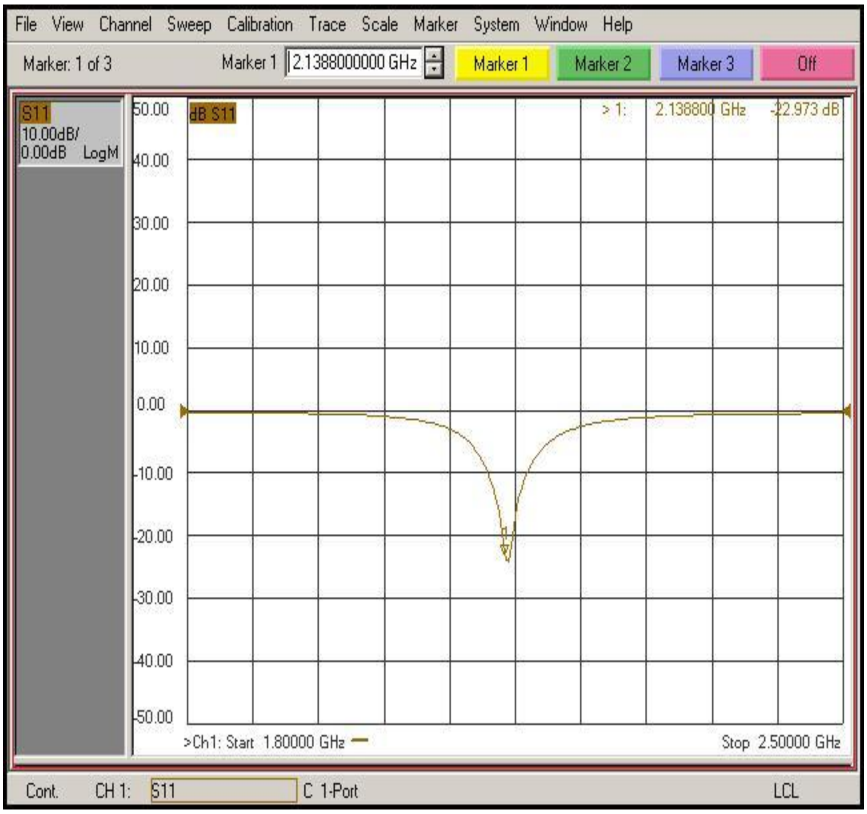


**Fig.9**. Measured Result of S11 of Ant2.

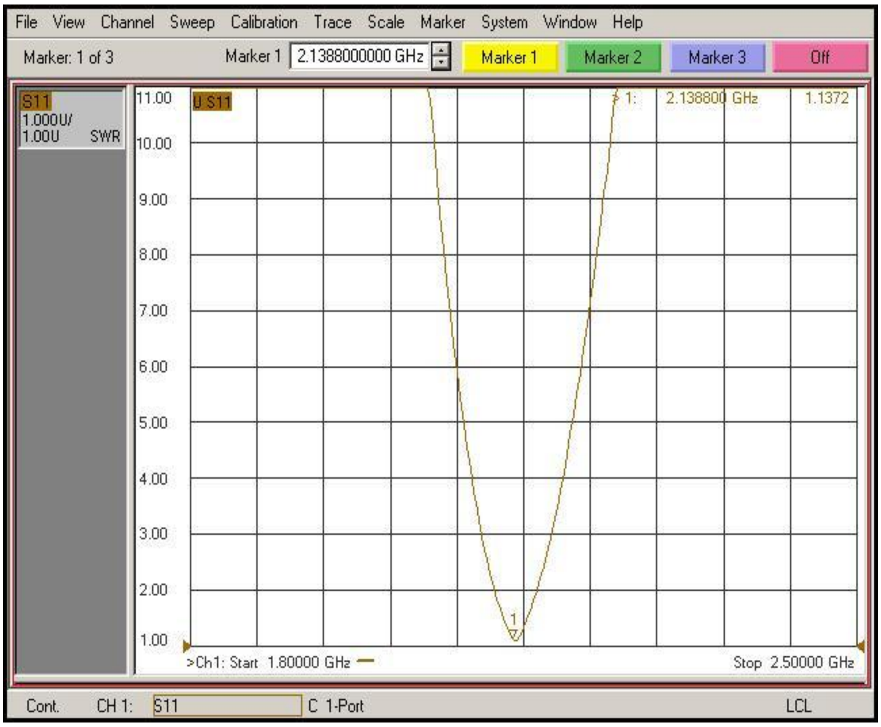


**Fig.10.** Measured Result of VSWR of Ant2.

## III. CONCLUSION

In this paper a circularly polarized fractal geometry antennas are presented for LTE downlink communication at 2.1GHz.Proposed antennas are designed using two symmetric slots& truncated corners on the diagonal axis to get circular polarization. Indentation factor at the fractal boundary is well optimized to get good result & has got overall antenna parameters improved. Antenna is fabricated & tested. Tested result & simulated results are in good agreements. Physical size of presented antenna is small and miniaturization is done to get reduced size. Hence, this antenna can resolve many issues pertaining to antenna parameters while communicating over LTE band.

## REFERENCES


[1]. S.Sesia. I.Toufik, and M Baker, LTE-The UMTS Long Term Evolution: From Theory to practice Chichester. U.K: Wiley, 2009.

[2]. Leonardo Lizzi and Andrea Massa, "Dual Band Printed Fractal Monopole Antenna for LTE Applications,"IEEE Antennas and WirelessPropagationLetters, vol.10, pp.760-7763,DOI.10.1109/LAWP.2011.2163051.

[3]. V.V.Reddy and N V S N Sarma, "Poly Fractal Boundary Circularly Polarized Microstrip Antenna for WLAN/Wi-MAXWirelessApplication,"DefenseScienceJournal,Vol.65,pp.379-384,DOI:10.14429/dsj.65.8905,2015.

[4]. R.A.Bhatti, S.Yi, and S.Park, "Compact antenna array with port decoupling for LTE –standardized mobile phones,"IEEE Antenna Wireless Propagation Letter, vol 8, pp1430-1433, 2009.

[5]. AshwiniK. Arya, Nguyen Viet Anh, Raos.Aziz,Byeong yong Park and Seong-Ook Park, "Dual Polarized Dual Antennas for 1.7-2.1GHz-LTE Base Station,"IEEE Antennas and Wireless Propagation Letters,vol.14,2015.

[6]. V.V.Reddy and N V S N Sarma, "Compact Circularly Polarized Asymmetrical Fractal Boundary Microstrip Antenna for Wireless Applications,"IEEE Antennas and Wireless Propagation Letters, Vol.13pp118-120,2014.

[7]. Federico Viani,"Dual Band Sierpinski Pre-Fractal Antenna for 2.4GHz-WLAN & 800MHz–LTE WirelessDevices," Progress In Electromagnetic Research, Vol.35,pp63-71,2013.

[8]. Viani, F., M. Salucci, F. Robol, G. Oliveri, and A. Massa, "Design of a UHF RFID/GPS fractal antenna for logistics management,"Journal of Electromagnetic Waves and Applications, Vol. 26, No. 4, 480–492, 2012.

[9]. Viani, F., M. Salucci, F. Robol, and A. Massa, "Multiband fractal Zigbee/WLAN antenna for ubiquitous wireless environments," Journal of Electromagnetic Waves and Applications, Vol. 26, Nos. 11–12, 1554–1562, Aug. 2012.

[10]. Lizzi, L., R. Azaro, G. Oliveri, and A. Massa, "Multiband fractal antenna for wireless communication systems for emergency management," Journal of Electromagnetic Waves and Applications, Vol. 26, No. 1, 1–11, 2012.

[11]. Carles Puente-Baliarda, Jordi Romey, Rafel Pous and Angel Cardama, "On the behavior of the Sierpinski Multiband Fractal Antenna,"IEEE Transaction on Antennas & Propagation, vol46 No: 4, pp517-524, April 1998.

[12]. Karim, M. N. A., M. K. Abd Rahim, H. A. Majid, O. B. Ayop, M. Abu, and F. Zubir, "Log periodic fractal Koch antenna for UHF band applications," Progress In Electromagnetics Research, Vol. 100, 201–218, 2010.

[13]. Xu, H.-Y., H. Zhang, X. Yin, and K. Lu, "Ultra-wideband Koch fractal antenna with low backscattering cross section," Journal of Electromagnetic Waves and Applications, Vol. 24, Nos. 17–18, 2615–2623, 2010.

[14]. Siakavara, K., "Novel fractal antenna arrays for satellite networks: Circular ring Sierpinski carpet arrays optimized by genetic algorithms," Progress In Electromagnetic Research, Vol. 103, 115–138, 2010.

[15]. Lizzi,L.,F.Viani,E.Zeni, and A.Massa," DVBH/GSM/UMTS planar antenna for multimode wireless devices," IEEE Antennas Wireless Propag. Letter, Vol. 8, 568–571, 2009.

[16]. Azaro, R., F. Viani, L. Lizzi, E. Zeni, and A. Massa, "A monopolar quad-band antenna based on a Hilbert self-affine prefractal geometry," IEEE Antennas Wireless Propag. Letter. Vol. 8, 177–180, 2008.

[17]. Naghshvarian-Jahromi, M., "Novel miniature semi-circular-semi fractal monopole dual band antenna," Journal of Electromagnetic Waves and Applications, Vol. 22, Nos. 2–3, 227–237, 2008.

[18]. Shashi Bhushan Kumar, Dr P K Singhal,"Performance Tested of Microstrip Fractal Antenna for Wireless Communication",CIIT International Journal of Wireless Communication, Online: ISSN: 0974-9740, Dec2012, DOI: WC122012010

[19]. S B Kumar ,Dr. P K Singhal, "On The investigation of a Sierpinski's Carpet Microstrip Fractal Antenna, "Published in International of Engineering Science & Advance Technology ,India, Vol.2, pp 200-203,.March-April 2012


## About The Authors

**S. B. Kumar** was born in Dec1974 in jehanabad, Bihar, India. He received his M.Tech from MITS Gwalior, MP, and India in 2004. His research interests include Microwave Engineering, Microstrip antenna Specially Fractal antenna. He has been Pursuing Ph.D Degree from RGPV, Bhopal, MP. He has almost 20 publications in journals and Conferences. He has almost 12yrs experience in teaching at Bharati Vidyapeeth's college of Engineering, New Delhi.

P. K. SINGHAL (*1965) received the B.E. and Ph.D.degrees in Electronics Engineering from Jiwaji University, Gwalior, India, in 1987 and 1997, respectively, and the M.Tech. degree in Microwave Electronics from the University of Delhi, Delhi, India, in1989.Currently,he is working as Professor, in the Department of Electronics Engineering, Madhav Institute of Technology and Science, Gwalior, India. He has about 90 publications to his credit at the national and international level. His research interest includes electromagnetic, communication systems,micro-wave circuits and antennas. Dr. Singhal is a Life Member of the India Society for Technical Education (ISTE), the Computer Society of India (CSI), the Institution of Engineers (India), and Institute of Electronics and Telecommunication Engineers (I.E.T.E.), New Delhi, India.

*S.B.Kumar . "Investigation of Circularly Polarized Fractal Antenna At 2.1ghz For LTE Application." International Journal of Engineering Research and Development, vol. 08, no. 01, 2018, pp. 18–50.