A Low Profile Circularly Polarized Triple Band Antenna for Diverse Applications

[1]Ch Murali Krishna, [2]P Baby Chandini Devi, [3]V Venkata Abhishek, [4]S Sai Dhanush, [5] Sk Sayyad
[1]Assistant Professor, [2,3,4,5] UG Student, Dept.of ECE, Ramachandra College of Engineering, Eluru, AP, India, 534007
[1]krishnasri780@gmail.com , [2]chandinichan456@gmail.com, [3]venkataabhishek1@gmailcom, [4]saidhanush1998@gmail.com, [5]shaiksayyad999@gmail.com

Abstract - A compact low profile smaller size (0.608λ x 0.456λ x 0.024λ) triple band antenna for diverse applications is proposed. Multiband operation is accomplished by developing peano fractal on square patch and step shape unit cell DGS implemented. This antenna centered at 2.56GHz, 6.16GHz and 10.50GHz with fractional bandwidths are 380MHz, 670MHz and 1220MHz respectively. This antenna supports circular polarization at resonant frequencies. The main advantage of this antenna is smaller in size, multiple resonances with maximum peak gains, circularly polarized and high radiation efficiency. This antenna has also good impedance matching and radiation characteristics. This antenna is most suitable for fixed mobile, earth-to-earth communication applications.

Keywords – *Peano curve; DGS; Tripleband; Circular polarization; Radiation efficiency.*

I. INTRODUCTION

Wireless Communication plays a Major role in technology. It involves in transmission of the signals over Thousands of Km without the help of cables or wires. A Vast Growth in wireless Technology. Antennas Plays a major role in telecommunication. Antennas are basic components of any electrical circuit as they provide interconnecting links between transmitter and free space or between free space and receiver. In Present generation currently using Wireless systems are Cellular System, Wireless LANS, Satellite System, Paging System, PANS (Bluetooth).

Recently miniaturized antennas has gained significant lead in the field of modern wireless communication technology because of smaller in size, low profile, easily integrated with circuits, simultaneous occurrence of multibands, easy fabrication, maximum gain and radiation efficiency [1-3]. This microstrip antenna is also known as internal antenna. It supports both linear and circular polarization.

Regarding this literature survey reports huge number of methods are implemented to obtain multiband antennas such as etching slots in patch and ground [4-9], fractal antennas [10-12], different parasitic elements [13-15] etc. From all these methods, fractals are preferred because of self-similar structure & space filling property [16].

In this paper, a low profile hexagon modeled peano curves loaded on square patch antenna, which is suitable for diverse applications. Section 2 explains about the existing models and its results discussion. Section 3 describes about the design implementation of proposed structure with simulation results and its discussion. Section 4 demonstrates the design summary of proposed antenna. Section 5 shows the comparison of proposed antenna characteristics with existed works. Finally section 6 concludes this work with applications in conclusion.

II. EXISTIND METHODS

Figure 1 shows the initiator and generator of the Giuseppe peano curve [17]. Figure 2(a-c) shows the rectangular, circular and triangular modeled peano curves loaded on square patch antenna [18-20]. Figure 3 shows the simulated reflection coefficient characteristics of these antennas.

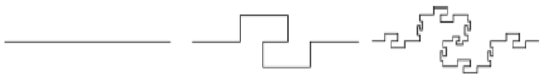
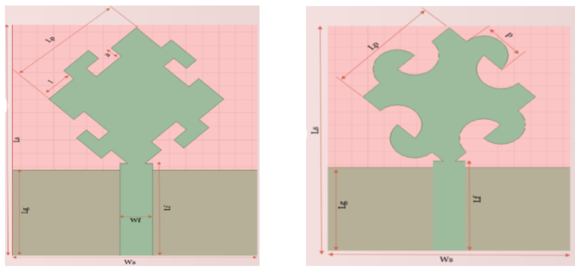


Fig.1: Initiator and generator of the Giuseppe peano fractal



(a) RGPF (b) CGPF

(c) TGPF

Fig 2: Peano curves loaded on square patch antenna (RGPF- Rectangular modeled peano curve, CGPF- Circular modeled peano curve, TGPF- triangular modeled peano curve)

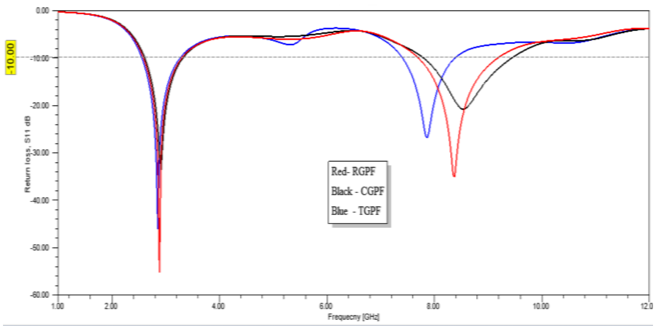


Fig 3: Reflection coefficient characteristics comparison of existing models

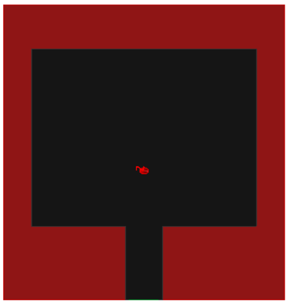
From figure 3, red colour solid line shows the return loss characteristics of RGPF. This antenna resonates at two frequencies such as 2.89GHz, 8.38GHz with their impedance bandwidths are 720MHz (2.59-3.31GHz), 1480MHz (7.70-9.18GHz). Black colour solid line indicates the S_{11} characteristics of CGPF. This antenna resonates at two frequencies such as 2.92GHz, 8.53GHz with their bandwidths are 710MHz (2.62-3.33GHz), 1650MHz (7.80-9.45GHz). Blue colour solid line also indicates return loss characteristics of TGPF, which resonates at 2.86dB, 7.87dB with their impedance bandwidths are 720MHz (2.56-3.28GHz), 980MHz (7.41-8.39GHz).

From these observations, fractal loaded patch antenna only limited two bands because of its easier structure.

III. PROPOSED ANTENNA DESIGN METHODOLOGY

In this a hexagonal shaped peano curve loaded on square patch antenna with defected ground structure (DGS) is proposed. The essential design requirements of microstrip patch antenna are resonant frequency (f_r), dielectric constant (ε_r) and thickness (h). The proposed antenna has been simulated on FR-4 epoxy material with dielectric constant 4.4 and loss tangent is 0.02 using High frequency Structure Simulator (HFSS) tool.

Figure 4 shows the implementation of proposed radiating element on FR-4 epoxy with various iterations. All these dimensions mentioned on figures are represented in table 1.



(a) Zeroth iteration

(b) First iteration

(c) Second iteration

Fig 4: Iterations of the proposed radiating element

Table 1: Parameters indicated on designs (All the units are in mm)

Parameters	Ls	Ws	Lf	W_f	L_g
mm	40	30	10	4	10
Parameters	**Lp**	**L**	**W**	**p**	**G**
mm	15	4.28	1.7	6	6
Parameters	W_g	L_{g1}	L_{g2}	g_1	**C**
mm	20	5	4	2.5	3.5

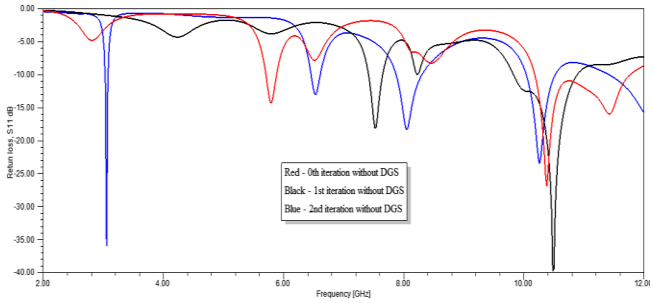
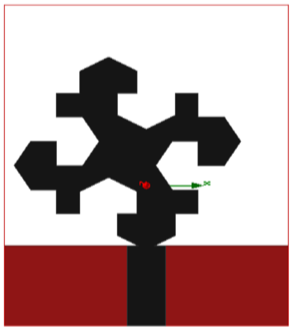


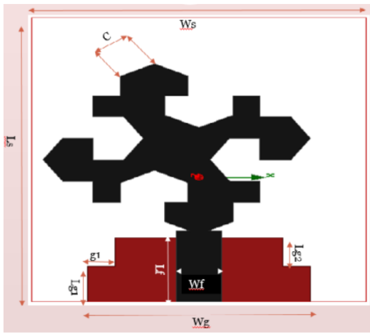
Fig 5: Return loss characteristics comparison of various iterations shown in fig 4.

From figure 5, observe that by increasing the number of iterations on the patch, it produces multiple bands at various resonant frequencies but the drawback is it has less reflection coefficient values. So to enhance the performance characteristics of proposed radiating element, DGS introduced to this structure. Figure 6 shows the development of proposed antenna structure.

(a) full ground



(b) Partial Ground



(c) Proposed DGS

Fig 6: Implementation of DGS for proposed radiating element

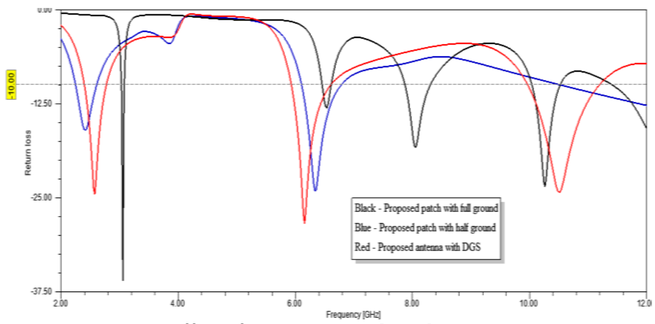


Fig 7: Effect of DGS on return loss characteristics.

Apart from the return loss characteristics, proposed radiating element with step model DGS achieves multiple bands than existed methods. This proposed antenna resonates at three frequencies such 2.58GHz, 6.16GHz and 10.50GHz. The reflection coefficients at their resonant frequencies are -24.56dB, -28.37dB and -24.20dB. The corresponding impedance bandwidth of each band are 380MHz (2.40-2.78GHz), 670MHz (5.94-6.61GHz) and 1220MHz (9.97-11.19GHz) respectively.

Figure 8 shows the input impedance behavior of the proposed antenna. This antenna has impedance of (43.8+j0.7)Ω, (53.3+j2.0)Ω and (44.3+j1.3)Ω at resonant frequencies 2.56GHz, 6.16Ghz and 10.50GHz respectively.

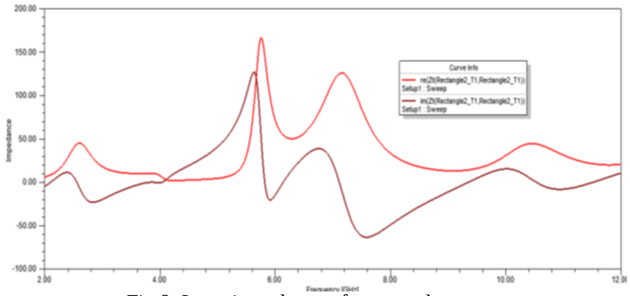
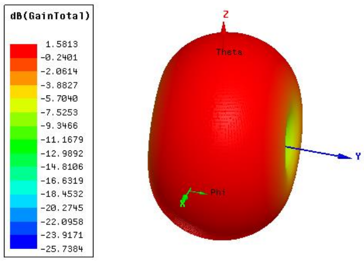
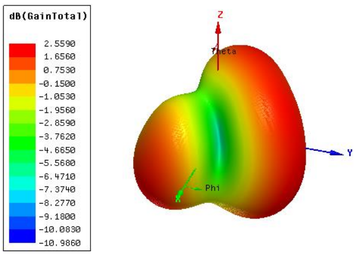


Fig 8: Input impedance of proposed antenna

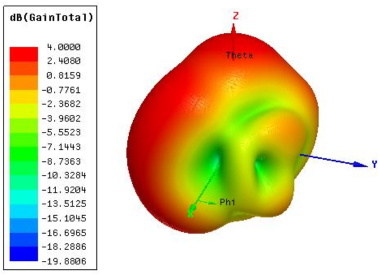
Figure 9 shows the 3D gain polar plots of proposed antenna at their resonant frequencies. The maximum peak gains at their bands are 1.58dB, 2.56dB and 4.0dB. Figure 10 shows the radiation patterns of the proposed antenna at resonant frequencies.



(a) 2.56GHz

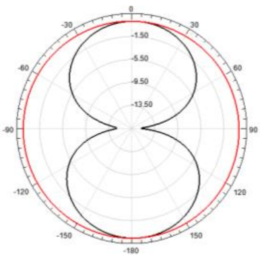


(b) 6.16GHz

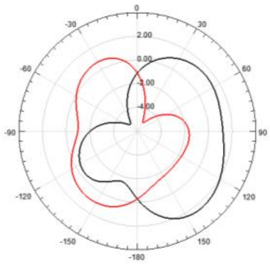


(c) 10.50GHz

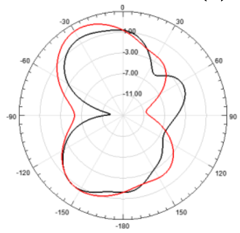
Figure 9: 3D gain plots at triple band proposed antenna



(a) 2.56dB



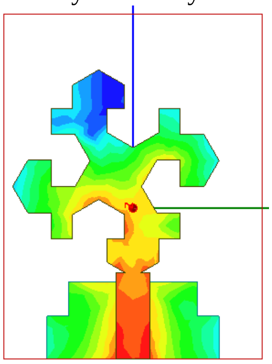
(b) 6.16GHz



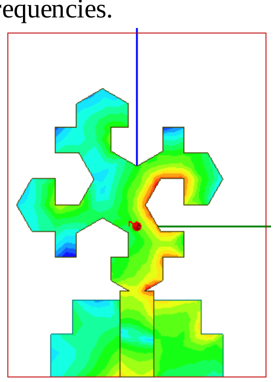
(c) 10.50GHz

Figure 10: Radiation patterns of proposed antenna (Red – E plane & Black –H plane)

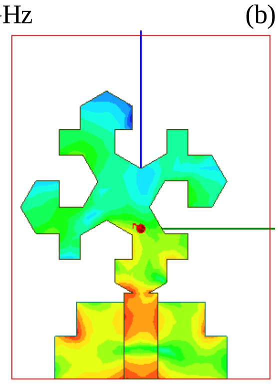
The surface current distributions of proposed antenna are shown in figure 11. It can be studied that this antenna is differently excited by different frequencies.



(a) 2.56GHz



(b) 6.16GHz



(c) 10.50GHz

Figure 11: Magnitude surface current distributions of proposed antenna

Figure 12 shows the axial ratio report of proposed antenna. From this observation, this curve has less than 3dB values at resonant frequencies. This antenna supports circular polarization.

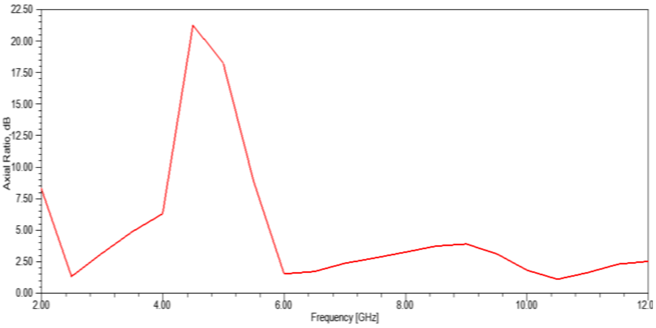


Fig 12: Axial ratio of proposed antenna

IV. DESIGN SUMMARY OF PROPOSED ANTENNA

Table 2 shows the electrical and far filed reports of proposed antenna. Table 3 shows the computed parameters of proposed antenna.

Table 2: Design summary of proposed antenna

Band	Resonant frequency, f_r	Reflection coefficient, S_{11} dB	Impedance Bandwidth	VSWR	Max. Peak Gain	Radiation direction
1	2.58GHz	-24.56dB	2.40-2.78GHz = 380MHz	1.12	1.58dB	Omni direction
2	6.16GHz	-28.37dB	5.94-6.61GHz = 670MHz	1.07	2.55dB	Unidirectional
3	10.5GHz	-24.28dB	9.97-11.19GHz = 1220MHz	1.13	4.00dB	Bidirectional

Table 3: Computed antenna parameters of proposed antenna

Quantity	At f_{r1}=2.56GHz	At f_{r2}=6.16GHz	At f_{r3}=10.50GHz
Max U	1.1451mW/sr	1.3443mW/sr	1.8974mW/sr
Peak Directivity	1.5131dB	2.079dB	2.765dB
Peak Gain	1.439dB	1.802dB	2.511dB
Peak Realized Gain	1.439dB	1.689dB	2.384dB
Radiated Power	9.509mW	8.123mW	8.623mW
Accepted Power	9.998mW	9.371mW	9.492mW
Incident Power	10mW	10mW	10mW
Radiation Efficiency	0.951	0.866	0.908
Front to Back Ratio	1.107	3.551	6.026
Decay Factor	0	0	0

V. PROPOSED versus EXISTED WORK

Table 4 shows the comparison of performance characteristics of proposed antenna with existed models.

Table 4: Performance characteristics comparison with existed models

Antenna	Bands	Resonant frequency	Reflection coefficient	Impedance Bandwidth	VSWR	Gain
RGPF [18]	1	2.88	-55.56	0.72GHz	1.02	3.41
	2	8.35	-34.40	1.48GHz	1.21	2.34
CGPF [19]	1	2.89	-33.40	0.71GHz	1.38	3.41
	2	8.56	-21.13	1.65GHz	1.76	2.16
TGPF [20]	1	2.84	-45.36	0.72GHz	1.04	3.40
	2	7.86	-26.80	0.98GHz	1.64	2.98
HGPF/ Proposed work	1	2.58	-24.56	380MHz	1.12	1.58
	2	6.16	-28.37	670MHz	1.07	2.55
	3	10.5	-24.28	1.22GHz	1.13	4.00

VI. CONCLUSION

A miniaturized triple band antenna loaded with hexagonal shaped peano structure and step type unit cell DGS is proposed. The main advantage of this design is smaller in size 30mm x 40mm and it has high efficiency at their resonant frequencies. Thus antenna resonates at 2.56GHz, 6.16GHz and 10.50GHz frequencies. This antenna is suitable for the applications of fixed mobiles except aeronautical mobile, broadcasting-satellite S5.413 S5.416, earth-to-space communications, mobile-S5.149

S5.440 S5.458, Amateur-Satellite and mobile radio locations. This antenna has good impedance matching characteristics, high radiation efficiency and good FBR at the centered frequencies.

REFERENCES

1. Cao, Y. F., Cheung, S. W., & Yuk, T. I. (2015). A multiband slot antenna for GPS/WiMAX/WLAN systems. IEEE Transactions on Antennas and Propagation, 63(3), 952-958.
2. Mandal, K. (2016). Seven-band comb-shaped microstrip antenna for wireless systems. Progress In Electromagnetics Research, 59, 15-20.
3. Ali, T, Pathan S, Biradar R. C. (2018) Multiband, frequency reconfigurable, and metamaterial antennas design techniques: Present and future research directions, Internet Technology Letters, 2018;e19. https://doi.org/10.1001/itl2.19
4. Ali, T., & Biradar, R. C. (2018). A triple band highly miniaturized antenna for WiMAX/WLAN applications. Microwave and Optical Technology Letters, 60(2), 466-471
5. Ali, T., Khaleeq, M. M., & Biradar, R. C. (2018). A multiband reconfigurable slot antenna for wireless applications. AEU-International Journal of Electronics and Communications, 84, 273-280.
6. Prasad, K. D., Ali, T., & Biradar, R. C. (2017, May). A compact slotted multiband antenna for L-band and WLAN applications. In Recent Trends in Electronics, Information & Communication Technology (RTEICT), 2017 2nd IEEE International Conference on (pp. 820-823). IEEE.
7. Bao, J., Huang, Q., Wang, X., & Shi, X. (2014). Compact multiband slot antenna for WLAN/WiMAX operations. International Journal of Antennas and Propagation, 2014.
8. Ali, T., & Biradar, R. C. (2017). A compact hexagonal slot dual band frequency reconfigurable antenna for WLAN applications. Microwave and Optical Technology Letters, 59(4), 958-964.
9. Ali, T., & Biradar, R. C. (2017). A miniaturized Volkswagen logo UWB antenna with slotted ground structure and metamaterial for GPS, WiMAX and WLAN applications. Progress In Electromagnetics Research, 72, 29-41.
10. Ali, T., Aw, M. S., & Biradar, R. C. (2018). A fractal quadband antenna loaded with L-shaped slot and metamaterial for wireless applications. International Journal of Microwave and Wireless Technologies, 1-9.
11. Fathima, N., Nayana, K. S., Ali, T., & Biradar, R. C. (2017, May). "A miniaturized slotted ground fractal Koch multiband antenna for wireless applications", In Recent Trends in Electronics, Information & Communication Technology (RTEICT), 2017 2nd IEEE International Conference on (pp. 251-255). IEEE.
12. Taghadosi, M., Albasha, L., Qaddoumi, N., & Ali, M. (2015). Miniaturised printed elliptical nested fractal multiband antenna for energy harvesting applications. IET Microwaves, Antennas & Propagation, 9(10), 1045-1053.
13. Sanz-Izquierdo, B., Batchelor, J., & Langley, R. (2004), Multiband printed PIFA antenna with ground plane capacitive resonator. Electronics Letters, 40(22), 1391-1392.
14. Kim, K. J., Lee, S., Kim, B. N., Jung, J. H., & Yoon, Y. J. (2011). Small antenna with a coupling feed and parasitic elements for multiband mobile applications. IEEE Antennas and Wireless Propagation Letters, 10, 290-293.
15. Wang, H., & Zheng, M. (2011). An internal triple-band WLAN antenna. IEEE Antennas and Wireless Propagation Letters, 10, 569-572.
16. Filipe Monteiro Lopes, "Fractal Antennas for Wireless Communication Systems" (Thesis), June 2009
17. Homayoon Oraizi, Shahram Hedayati, "Miniaturization of Microstrip Antennas by the Novel Application of the Giuseppe Peano Fractal Geometries", IEEE Transactions on Antennas and Propagation, vol.60, No.8, August2012
18. Navpreet Kaur, Nipun Sharma, Naveen Kumar, "RF Energy Harvesting and Storage System of Rectenna: A Review", Indian Journal of Science and Technology 11(25):1-5 · July 2018, DOI:10.17485/ijst/2018/v11i25/114309
19. Gaurav Pal Singh, Narinder Sharma, "Novel Design of Fractal Antenna using Giuseppe Peano Geometry for Wireless Applications", International Journal of Computer Applications (0975 – 8887), Volume 150 – No.7, September 2016, 29.
20. Narinder Sharma, Gaurav Pa Singh and Vipu Sharma, "Miniaturization of Fractal Antenna using Novel Giuseppe Peano Geometry for Wireless Applications", 1st IEEE International Conference on Power Electronics. Intelligent Control and Energy Systems, 2016

CH.MURALI KRISHNA is presently working as an assistant professor in the department of ECE, Ramachandra college of engineering, Eluru. He received his M.Tech degree in Electronics and Communication Engineering from S.R.K.R. Engineering College, Bhimavaram, India in 2018. He is currently working on Reconfigurable and MIMO antennas design.

P BABY CHANDINI DEVI is pursuing final year UG course in ECE course from Ramachandra College of Engineering, Eluru. Her areas of interests are design and analysis in communications and antennas.

V VENKATA ABHISHEK is pursuing final year UG course in ECE course from Ramachandra College of Engineering, Eluru. His areas of interests are antenna design analysis and electromagnetics equation solving.

S SAI DHANUSH is pursuing final year UG course in ECE course from Ramachandra College of Engineering, Eluru. His areas of interests are antennas and microwave engineering.

SHAIK SAYYAD is pursuing final year UG course in ECE course from Ramachandra College of Engineering, Eluru. His areas of interests are antenna and wave propagation.