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CIRCULARLY POLARIZED KOCH FRACTAL TRIBAND ANTENNA FOR WIRELESS COMMUNICATION APPLICATIONS

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ABSTRACT

A novel monopole asymmetric fractal micro strip antenna is designed and analyzed in this paper. The proposed Koch fractal monopole antenna is resonating at triband with circular polarization operation. Five diff structures - without slot (basic model), single slot (Iteration 1), double slotted (Iteration 2), triple slotted (Iteration 3), and optimized fractal slot (Iteration 4) are studied for circular polarization radiation. Perturbations in the structure for triband CP radiation are introduced by employing optimization in the asymmetrical Koch fractal curves as boundaries of a square patch and embedded triangular slots. The generated 3-dB axial ratios are analyzed with the simulation results demonstrate that the proposed antenna design is suitable for wireless communication applications.

Keywords: axial ratio (AR), circular polarization (CP), koch fractal, triband, wireless communications.

1. INTRODUCTION

With rapid development in advanced wireless communication systems, designing compact, multiband and Omni directional radiation patterns for multi systems are becoming essential as per the future requirements [1-2]. Several antennas have been proposed for dual band, triband and multiband applications. However their designs may increase the complexity, and may have large sizes and may have limited bandwidths [3]. Modern systems are able to support various applications operating at different frequency bands. Hence, there is a need for multiband CP antennas to eliminate the multipath effects and to make the data reception independent of orientation of the device [4-6].

Triband antennas based on circular-arc-shaped strips and asymmetrical strips have been covered in the literature, and resonance frequencies of multiband are controlled by the dimensions of the strips [7-9]. Triband antennas have been demonstrated using H-shape, U-shape, Hexagonal slot with slits, and dual annular shaped slot patch structures. However, most of these triband antennas are linearly polarized, and the fabrication complexity increases with complex structures in the design of the antenna. Single layer single probe fed triband CP antennas with slits on the patch and ground plane are available in the open literature [10-11]. Although these structures give CP at three bands, the generated 3-dB axial ratio Band width at tribands is very narrow [12]. In this paper we designed triband CP operation for wireless communication applications using Koch fractal concept to generate wide 3-dB axial ratio CP bandwidth.

Fractal antennas have already been proved to have some unique characteristics that are linked to the geometrical properties of fractals [13]. The self similarity property of fractals makes them especially suitable to design multi frequency antennas. Some fractal shapes have complex, convoluted shapes that can enhance radiation when used as antennas [14-15]. For instance some fractal loops can be designed to enclose a finite surface with an arbitrary large perimeter. Certain monopoles can be designed to have an arbitrary large length, although they can be constrained to fit a given volume. In this work coplanar waveguide fed monopole Koch fractal boundary patch is implemented for triband CP radiation. This paper will demonstrate the design procedure of triband fractal slot antenna and its performance characteristics in simulation with Finite element method (FEM) based HFSS tool.

2. ANTENNA GEOMETRY AND DESIGN PROCEDURE

The configuration of the proposed Circular polarized antenna in HFSS simulation is shown in Figure-1(A) and the prototyped model on FR4 substrate is shown in Figure-1(B).

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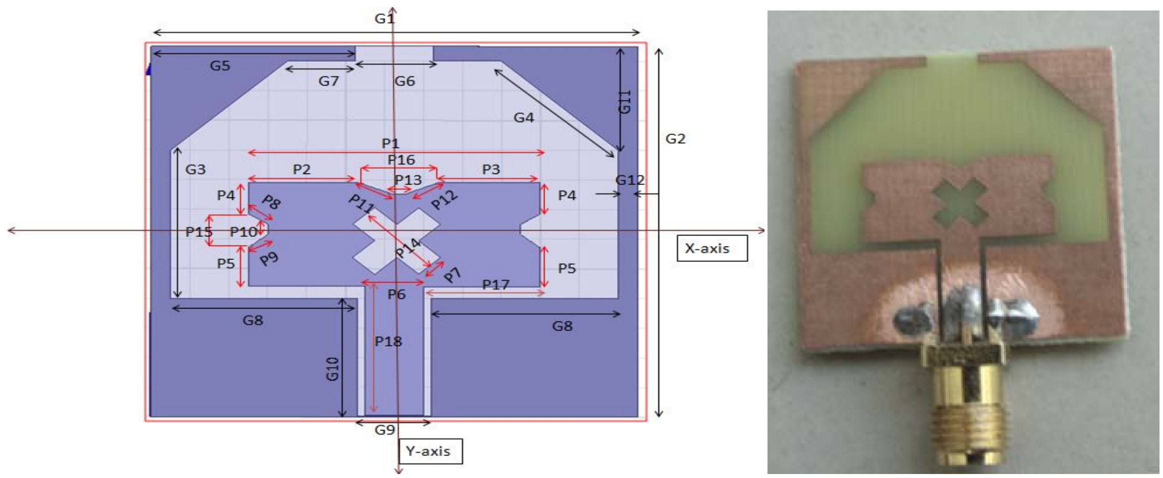

Figure-1(A). Proposed Koch fractal circularly polarized antenna (Iteration 4), **Figure-1(B).** Prototyped model.

Table-1. Proposed Koch fractal circularly polarized antenna dimensions.

G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
25	25	10	8.485	10.5	4	3.5	9.6	3.8	7.95

G11	G12	P1	P2	P3	P4	P5	P6	P7	P8
7.0	1	15	5.625	5.25	2.1	2.625	3	1.59	1.22

P9	P10	P11	P12	P13	P14	P15	P16	P17	P18
1.328	0.7	2.038	1.924	0.5	4.77	2.2	4.125	6	8.7

The specifications of the proposed model are shown in Table-1. The three sides of the square patch are replaced with Koch fractal curve to design the compact antenna for Circular polarization radiation. To excite two orthogonal modes of 90 degrees phase shift for good CP radiation at triband, proper asymmetry is implemented by rotating the fractal slot by 45 degrees as shown in the design. This slot is a scaled version of the main patch. Perturbation to the structure is inserted through edges, so that the feed point at lower side will not disturb the Koch fractal structure. To facilitate better understanding of the proposed triband CP operation mechanism, the HFSS simulation is carried out and the designed models starting with base model to iteration 4 as shown in Figure-2. The antenna models are designed on FR4 substrate of dielectric constant 4.4. The overall dimension of the proposed antenna is around 25x25x1.6 mm.

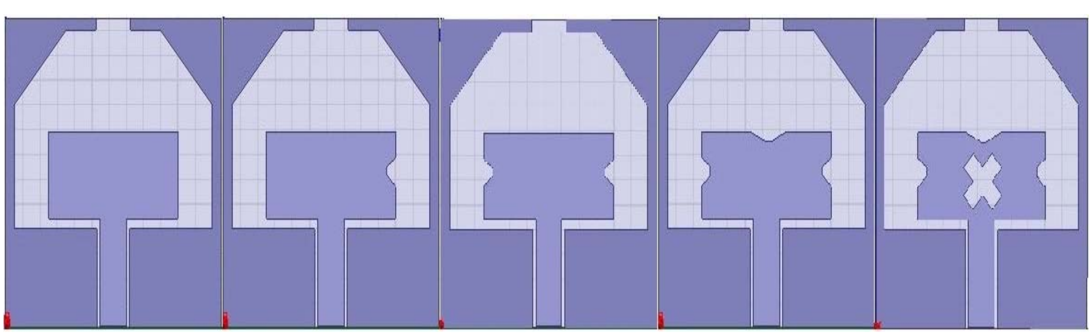

Figure-2. Different iterations of Koch fractal antenna.

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3. RESULTS AND DISCUSSIONS

One of the primary results from the antenna simulations are the S-parameters (magnitude and phase) plots Vs. frequency. The s-parameter plot show resonant frequencies and operating bandwidths for the microstrip patch antennas analyzed. Figure-3 shows the reflection coefficient characteristics of the antenna models with respect to the resonant frequencies. The base model is resonating at dual band with low bandwidth at the resonant frequencies. Even though the curve showing without resonating frequency for the base model, the reflection coefficient is negligible in the simulation and in the measurement this third band is not obtained. From iteration 1 to iteration 4, we can observe the improvement in the bandwidth as well as reflection coefficient as shown from the Figure-3. A notable observation from the return loss characteristics are observed that there is a sharp discontinuity in the curves at higher bands indicating the possibility of CP radiation. The first resonant band at 4.6GHz is excited by outer fractal curves and inner slot boundaries, thus a wide impedance bandwidth that covers wireless applications with 10-dB return loss bandwidth 65% (3GHz-6GHz) is obtained. The second resonant frequency band at 7.7GHz covers (FM-UWB transceiver) with 6.5% (7.5GHz-8GHz) bandwidth. The third frequency band at 10.28GHz is mainly due to the inner embedded fractal slot, and bandwidth is 4 % (10GHz-10.4GHz).

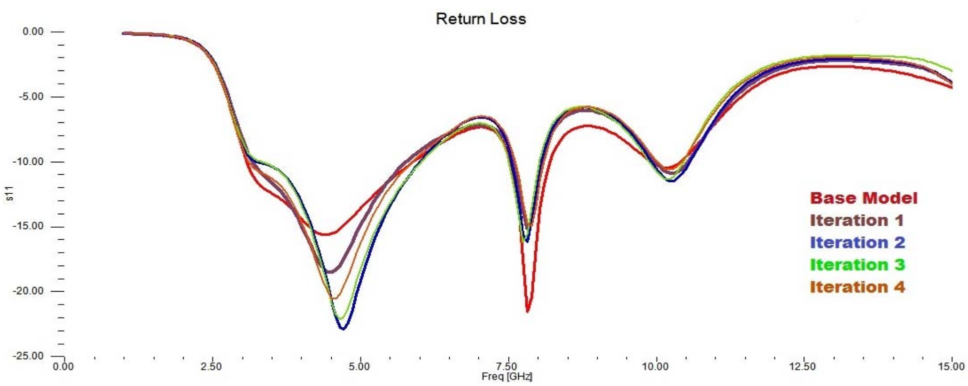

Figure-3. Return loss vs. frequency of the antenna models.

Iteration 4 is showing better impedance i.e., at fundamental resonant frequency impedance nearer to 50 ohms. Figure-4 shows the axial ratio curve for the antenna models at the resonant frequencies. It has been observed that axial ratio at the corresponding resonant frequencies for all the models are showing < 3dB. The axial ratio 3dB CP bandwidths are 1200 MHz, 487 MHz and 830 MHz at operating frequencies around 4.6, 7.7 and 10.28 GHz respectively.

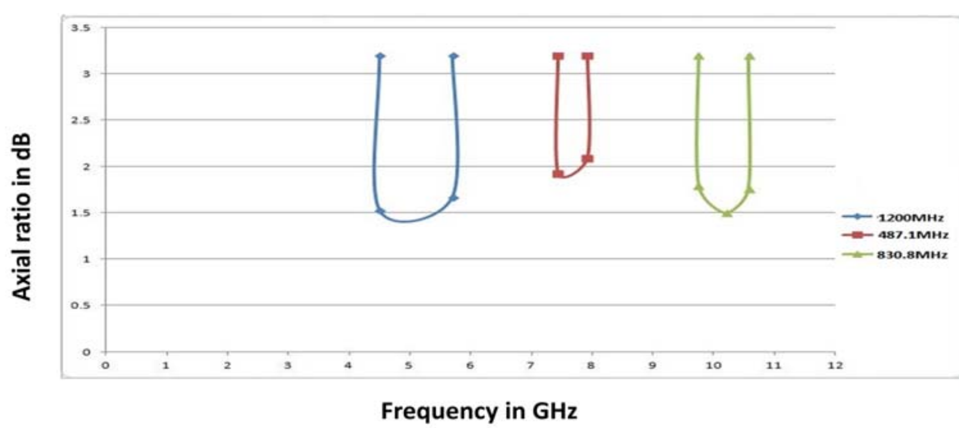

Figure-4. Axial ratio vs. frequency of the Koch fractal circularly polarized antenna.

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ARPN Journal of Engineering and Applied Sciences

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The proposed antenna radiation patterns in horizontal plane and vertical plane at its resonance frequencies are shown in Figure-5. The difference between these two radiation patterns produces the axial ratio in that direction. Due to smaller electrical length of the antenna at 10.28GHZ a broad side Omni directional radiation pattern can be observed from Figure-5 the cross polarization value is less than -36db in the E-plane and in the H-plane an 8 like radiation pattern with nulling at 90degrees, 270 degrees can be observed .the current model is giving larger axial ratio band width when compared with stacked antennas.

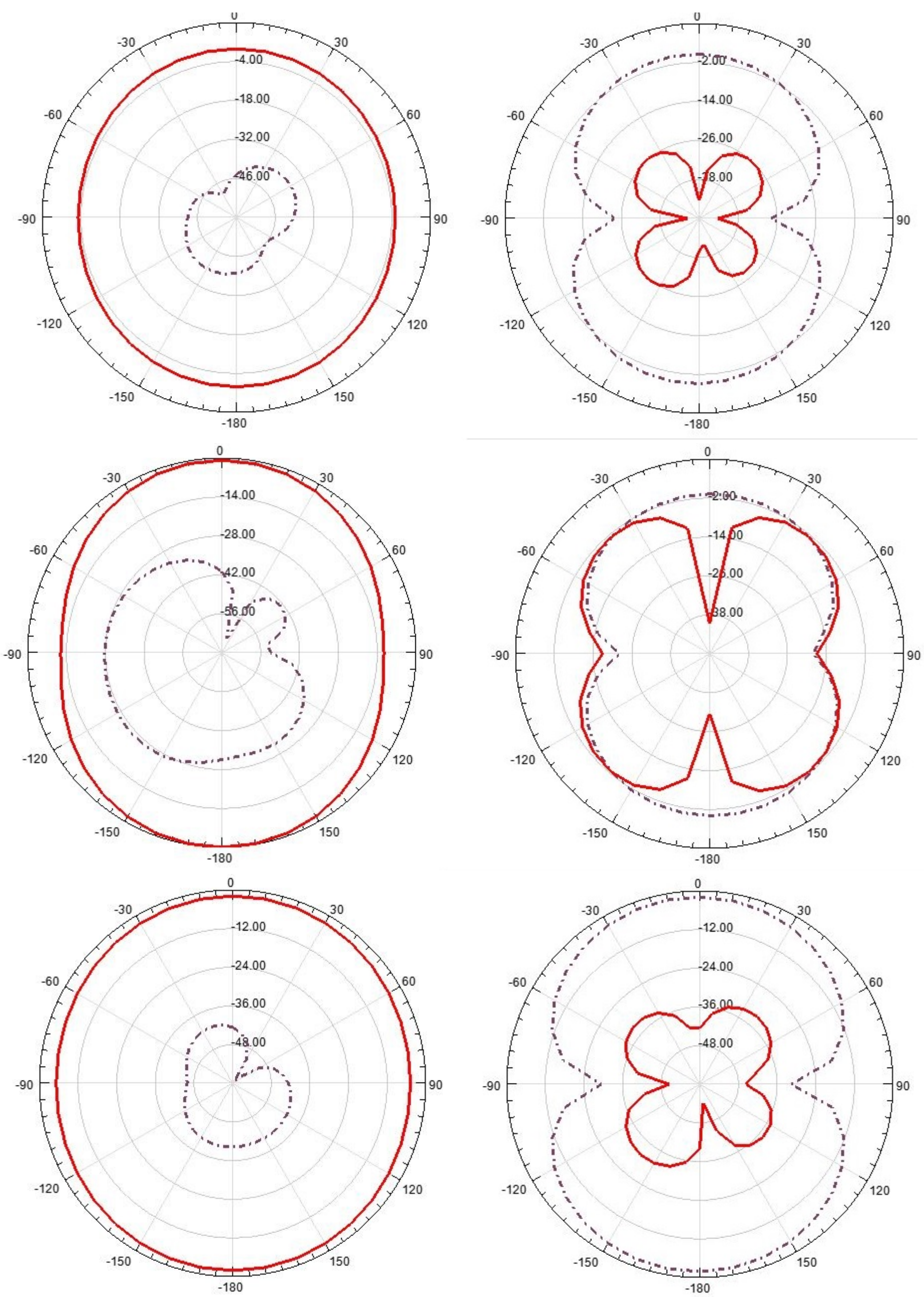

Figure-5. Radiation pattern in E and H-Plane for the proposed antenna model at 4.6, 7.7 and 10.28 GHz.

Figure-6 shows the current distribution over the surface of the proposed antenna at different resonant frequencies. A circular polarization can be observed from this figure. Most of the current density is focused at feed

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line for all resonant frequencies but a considerable current distribution can be observed for the proposed antenna at 7.7 GHz. Figure-7 shows the directivity of the antenna models at their resonant frequencies. Directivity of more than 3.3db at 10.28 GHZ for proposed model can be observed from Figure-7. Figure-8 shows gain of the antenna models with respect to their resonant frequencies. A maximum gain of more than 2.8 dB is obtained at higher resonant frequency for the circular polarized antenna. Figure-9 shows the efficiency of the antenna models with respect to their operating resonant frequencies. Iteration 1 and iteration 4 are giving efficiency more than 96 % at 4.6 GHz.

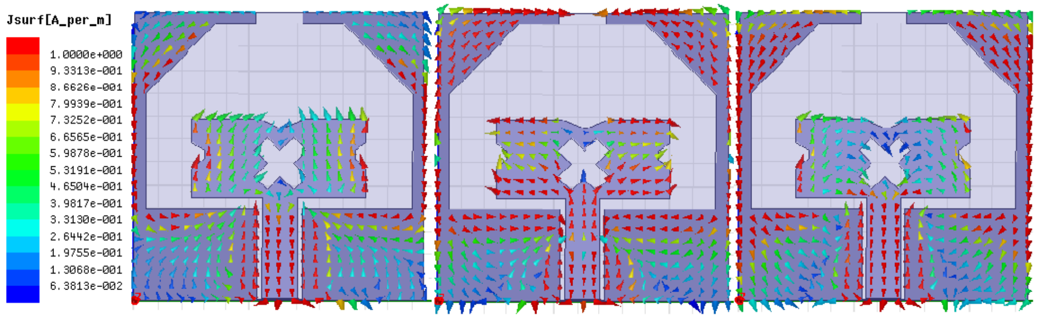

Figure-6. Current distribution of the proposed antenna at resonant frequencies 4.6, 7.7 and 10.28 GHz.

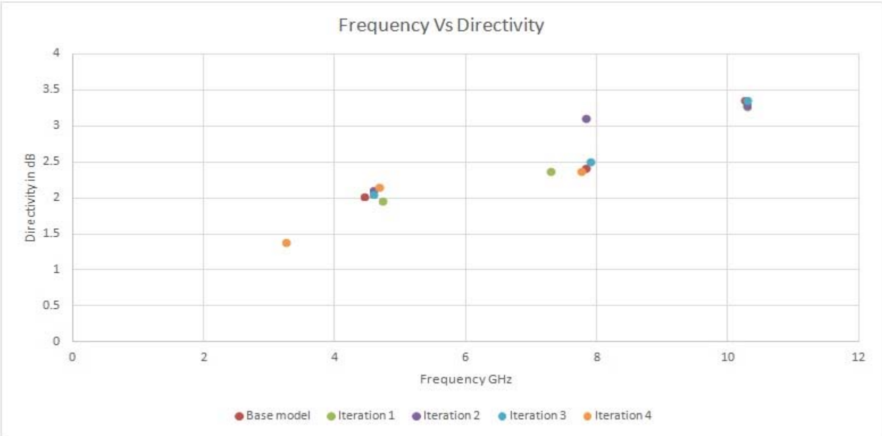

Figure-7. Frequency vs. directivity of the antenna models.

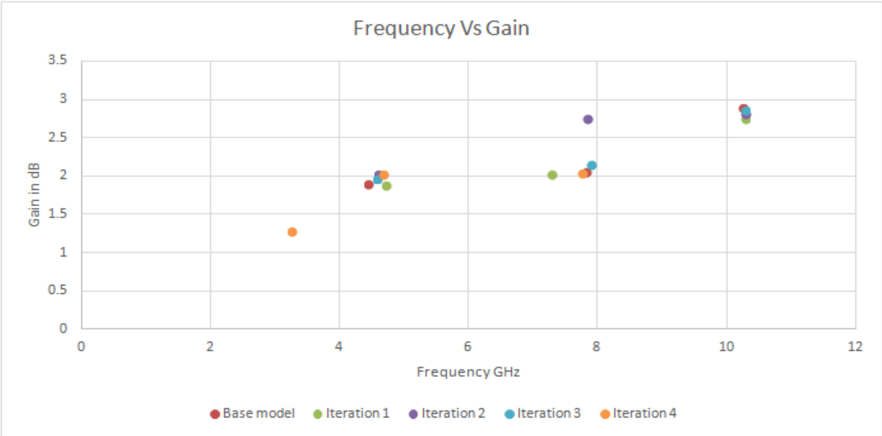

Figure-8. Frequency vs. gain of the antenna models.

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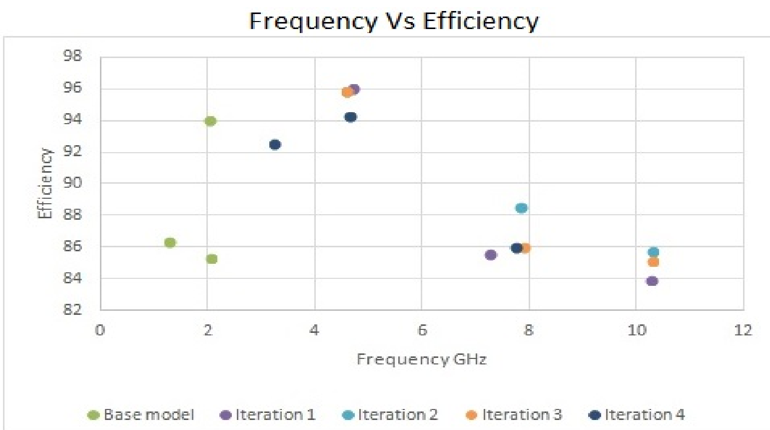

Figure-9. Frequency vs. efficiency of the antenna models.

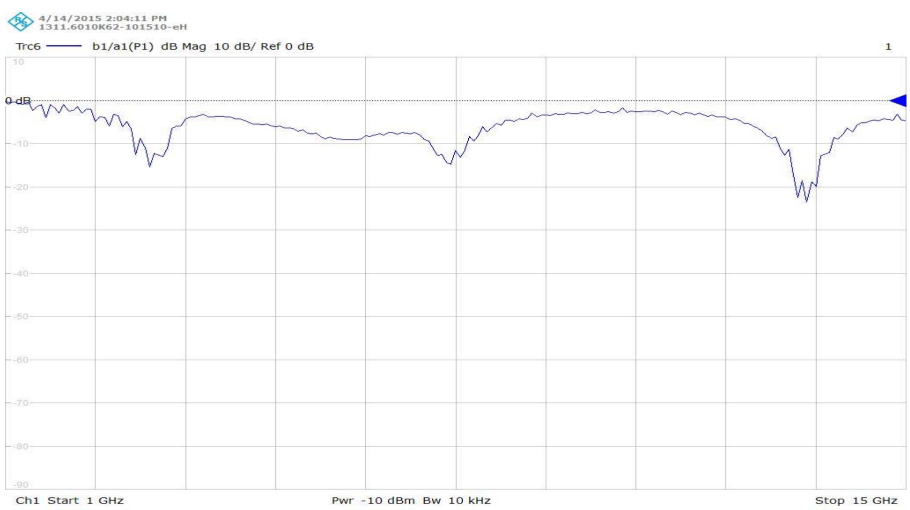

Figure-10. Measured Returnloss curve of Koch fractal circularly polarized antenna.

The measured result of the return loss from vector network analyzer is presented in Figure-10. R and S ZNB 20 VNA is used here to take the measured results of the antenna in frequency domain. It has been observed from the Figure-10 that the simulated and measured results are in good agreement with each other and the proposed antenna is showing triband characteristics with return loss less than -10 dB at the corresponding resonant frequencies.

CONCLUSIONS

A novel coplanar wave guide fed tri band circularly polarized Koch asymmetrical fractal monopole antenna has been proposed and analyzed in this paper. Circular polarized rectangular ,fractal slotted antenna for triband operation is studied and its performance characteristics are presented in this work .By optimizing feed and slot dimensions triband circular polarization is achieved. The proposed model showing axial ratio bandwidth of 1200 MHz, 488MHz and 830MHz at 4.6, 7.7 and 10.2GHZ, respectively. The circular polarized proposed antenna is highly suitable for the modern wireless communication systems with its excellent AR bandwidth and efficiency.

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REFERENCES

[1] Y. Sung. 2011. Dual-band circularly polarized pentagonal slot antenna. IEEE Antennas Wireless Propag. Lett. 10: 259-261.

[2] K. P. Yang and K. L. Wong. 2011. Dual-band circularly-polarized square microstrip antenna. IEEE Trans. Antennas Propag. 49(3): 377-382.

[3] B.T.P. Madhav, G. Vaishnavi, V. Manichandana, Ch Harinath Reddy, S. Ravi Teja , J. Sesi Kumar. 2013. Compact Sierpinski Carpet Antenna on Destructive Ground Plane. International Journal of Applied Engineering Research, ISSN 0973-4562. 8(4): 343-352.

[4] H. Zhai, Z. Ma, Y. Han and C. Liang. 2013. A compact printed antenna for triple-band WLAN/WiMAX applications. IEEE Antennas Wireless Propag. Lett. 12: 65-68.

[5] X.-S. Ren, Y.-Z. Yin, W.Hu and Y.-Q.Wei. 2010. Compact tri-band rectangular ring patch antenna with asymmetrical strips for WLAN/WiMAX applications. J. Electromagn. Waves Appl. 24: 1829-1838.

[6] B T P Madhav, Habibulla Khan, D Ujwala, Y Bhavani Sankar, Madhuri Kandepi, A Siva Nagendra Reddy, Davuluri Nagajyothi. 2013. CPW Fed Serrated Antenna Performance Based on Substrate Permittivity. International Journal of Applied Engineering Research, ISSN 0973-4562. 8(12): 1349-1354. IF: 0.1.

[7] B.T.P.Madhav, S. S. Mohan Reddy, Bandi Sanjay, D.Ujwala. 2013. Trident Shaped Ultra Wideband Antenna Analysis based on Substrate Permittivity. International Journal of Applied Engineering Research, ISSN 0973-4562. 8(12): 1355-1361. IF: 0.1.

[8] T.-H. Chang and J.-F. Kiang. 2013. Compact multi-band H-shaped slot antenna. IEEE Trans. Antennas Propag. 61(8): 4345-4349.

[9] W. C. Mok, S.H. Wong,K. M. Luk, and K. F. Lee. 2013. Single layer single patch dual band and triple band patch antennas. IEEE Trans. Antennas Propag. 61(8): 4341-4345.

[10] B T P Madhav, A Manikanta Prasanth, Sreeramineni Prasanth, Batchu Mohan Sai Krishna, Devani Manikantha, Usirika Sharmila NagaSai. 2015. Analysis of Defected Ground Structure Notched Monopole Antenna. ARPN Journal of Engineering and Applied Sciences, ISSN 1819-6608. 10(2): 747-752.

[11] M S S S Srinivas, T V Ramakrishna, B T P Madhav, N Bhagyalakshmi, S Madhavi, K Venkateswarulu. 2015. A Novel Compact CPW Fed Slot Antenna with EBG Structure. ARPN Journal of Engineering and Applied Sciences, ISSN 1819-6608. 10(2): 835-841.

[12] J. G. Baek and K. C. Hwang. 2013. Triple-band unidirectional circularly polarized hexagonal slot antenna with multiple L-shaped slits. IEEE Trans. Antennas Propag. 61(9): 4831-4835.

[13] B T P Madhav, VGKM Pisipati, Habibulla Khan, D Ujwala. 2014. Fractal shaped Sierpinski on EBG structured ground plane. Leonardo Electronic Journal of Practices and Technologies, ISSN 1583-1078. (25): 26-35.

[14] L. Wang, Y. X. Guo and W. X. Sheng. 2012. A single feed tri band circularly polarized dual annular slot antenna for wireless applications. J. Electromagn. Waves Appl. 26: 1389-1396.

[15] B T P Madhav, Jayasree Gogineni, Harini Appana, Jyothi Prathusha Chennam, Durga Sai Sruthi Thota, Priyanka Kotte. 2015. Analysis of Compact Coplanar Waveguide Fed Slot Antenna with EBG Structure. pp. 219-225.