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COMPACT LOG PERIODIC DIPOLE ARRAY ANTENNA FOR MULTIBAND APPLICATIONS USING S-FRACTAL CURVE

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Abstract

Log periodic dipole array antennas are introduced for the development of broadband applications. In this paper, a low return loss S-shape fractal implemented on the printed log periodic dipole antenna is presented. This proposed design consists of log periodic slots in the ground plane and their self-complimentary structure is on the micro strip layer. This design offers multiband operation with fair values of return loss, VSWR, gain and impedance bandwidth in the entire range of frequency operation. The proposed S-shape LPDA design resonates at 2.54GHz, 2.90GHz, 3.70GHz, 4.28GHz, 4.98GHz, 5.52GHz, 6.42GHz 7.48GHz, 8.12GHz, 8.82GHz and 9.40GHz for WiFi, WiMAX, WLAN, S-,C- and X-band applications with broad bandwidth.

Keywords: *Fractal Structure, Log Periodic Dipole Array, Multiband, Broad Bandwidth, Radiation Efficiency.*

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1. INTRODUCTION

Broadband wireless technologies have seen a rapid growth by the successful development of wireless applications like Bluetooth, WiFi, WLAN and WiMAX etc. The Federal Communication Commission (FCC) allotted a frequency band of 3.1-10.6GHz as a commercial Ultra-wide band (UWB) system.

Printed antennas are mostly used due to the ease of integration with microwave circuits and fabrication. A multiband antenna is an emerging device in many commercial applications which provides both transmission and reception at multiple frequencies. This antenna should be able to control the desired frequencies, impedance bandwidths, gain & polarizations.

Log periodic dipole array (LPDA) antennas are well known from1950's and their geometries are based on the rules of Isbell & Carrel [1-3]. In the past years, a number of Printed LPDAs have been proposed and many techniques were implemented to realize UWB characteristics. In[4], printed Log-periodic dipole array was designed using Arlon AD250 substrate with dielectric constant=2.5 and thickness=0.51mm over the operating range 4-18GHz and UWB characteristics were obtained in the range 4.25-13.25GHz i.e., in a relative bandwidth greater than 100%. In[5], Mode converter balunwas implemented on planar LPDA, this balun converts quasi TEM mode to full TEM mode with excitation current property (ECP), which operates in the range 1-4GHz to cover L & S-bands. In[6], it presents a low profile log periodic monopole array designed with elliptical shape elements in the log periodic manner to operate over bandwidth 1.5-6.8GHz and end-fire radiation direction is achieved.

To achieve the multiband resonances in the antenna design, several methods are available. There are many examples like slots cut in the design, defected ground structures (DGS) and development of fractals etc. From many literature surveys, Koch fractal design [7-9], U-slot[10] and slots etched in the ground[11] are designed to obtain multiband resonances.

The primary focus of this paper is on low power wireless application bands. The dipole element can be redesigned into S-shape like a construction of Giuseppe peano fractal [12]. By altering this design, the characteristics of UWB-PLPDA antenna have been converted to those of multiband PLPDA antenna.

2. ANTENNA DESIGN METHODOLOGY

Log periodic arrays consists radiating dipole elements arranged in Log-periodic manner. The frequency scaled logarithmically, there is only one region is radiating and is being shifted due to by varying the frequencies. The dimensions of the long and short dipole elements will achieve the operating bandwidth and another parameter is relative spacing or spacing factor (σ), chosen from the directivity (D) and scaling factor (τ) graph. In this array, radiating elements are arranged in 180^o phase shift by adjacent elements; these elements are away from their resonances and are mismatched (in the transmission region).

A log periodic dipole array (LPDA) antenna has been designed over the frequency range 2-8GHz with the directivity D_o=8dB, scaling factor τ=0.85 and spacing factor σ = 0.157. This antenna is milled on FR4 epoxy substrate with thickness h=1.6mm, dielectric constant, ε_r=4.4 and loss tangent tanδ=0.02. Figure 1 shows traditional / Euclidean

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LPDA antenna with 50Ω micro strip lines.For this LPDA design, the resonant length of the dipole element computed from the lowest operating frequency (f_{min}).The parameters shown in figure 1 are listed in table 1.

The average characteristic impedance of a dipole element is expressed as

$$Z_n = \frac{\eta_o}{\pi}\left[\ln\left(\frac{L_n}{a_n}\right) - 2.25\right] \quad (1)$$

WhereL_n=length of the n^{th} dipole element
a_n=radius of the n^{th} dipole element

The width of the radiating dipole element computed as

$$W_n = \pi * a_n \quad (2)$$

The relation between the geometries of the LPDA antenna follows the following relation:

$$\frac{1}{\tau} = \frac{l_2}{l_1} = \frac{l_{n+1}}{l_n} = \frac{R_2}{R_1} = \frac{R_{n+1}}{R_n} = \frac{w_2}{w_1} = \frac{w_{n+1}}{w_n} = \frac{s_2}{s_1} = \frac{s_{n+1}}{s_n} \quad (3)$$

where l_n=length of the n^{th} element
R_n=distance between the two elements
W_n=width of the n^{th} element
S_n=center to center spacing betwen the two elements.

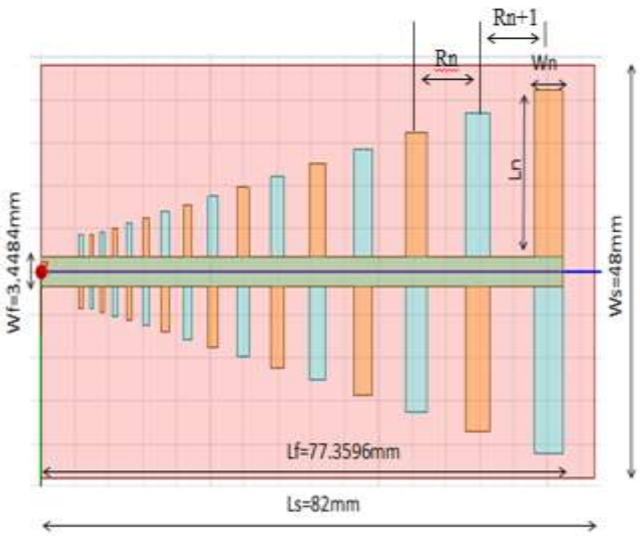
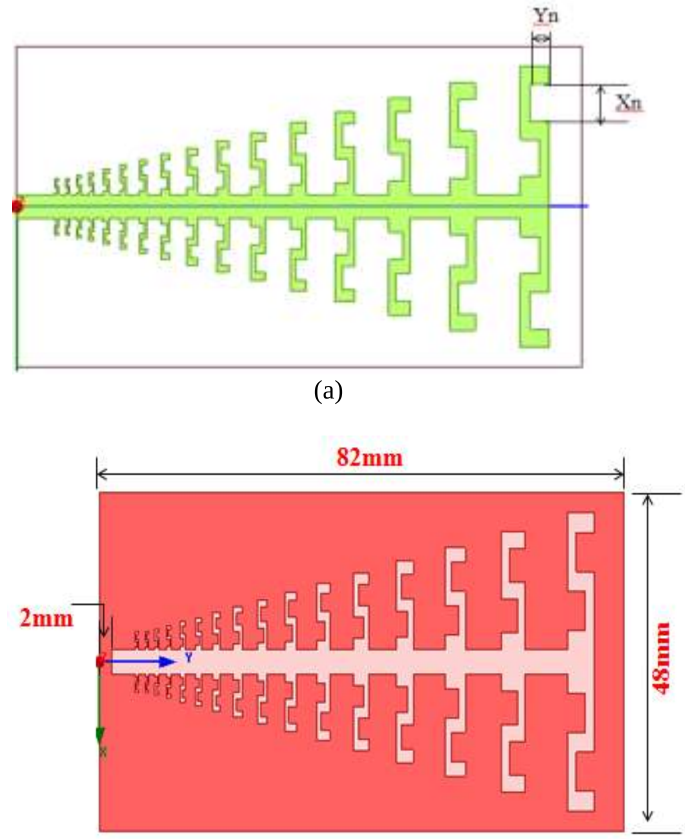


Fig-1: Designed printed log-periodic dipole array antenna for 2-8GHz

Table-1: Geometry of designed printed LPDA with fractal implementations

Dipole (n)	L_n	W_n	R_{n+1}	X_n	Y_n
1	2.5464	0.5558	----	0.7275	0.3705
2	2.9439	0.6426	1.5591	0.841	0.4284
3	3.4033	0.7429	1.8487	0.9723	0.4952
4	3.9345	0.8588	2.1372	1.1240	0.5725
5	4.5485	0.9929	2.4708	1.2994	0.6619
6	5.2584	1.1478	2.8564	1.5022	0.7652
7	6.0791	1.327	3.3022	1.7367	0.8846
8	7.0279	1.5341	3.8175	2.0077	1.0227
9	8.1247	1.7735	4.4134	2.3211	1.1823
10	9.3927	2.0503	5.1021	2.6834	1.3668
11	10.8587	2.3703	5.8984	3.1022	1.5802
12	12.5534	2.7403	6.819	3.5863	1.8268
13	14.5126	3.1679	7.8833	4.1464	2.1119
14	16.7776	3.6624	9.1136	4.7936	2.4415
15	19.3961	4.234	10.536	5.5412	2.8226

The dipole elements are modified into S-shape, which interned enhances the impedance bandwidth characteristics. By doing this phenomenon, the Ultra wide band (UWB) characteristics can be changed to multiband. Figure 2 shows the proposed antenna design with the parameters. The parameters are listed in table 1. The overall size of the antenna is 82mm x 48mm x 1.6mm. This design is simulated using High frequency structure simulator (HFSS).



(a)

(b)

Fig-2: Proposed antenna design with parameters

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3. RESULTS & DISCUSSION

3.1 Return Loss Characteristics

For the Euclidean LPDA antenna (as shown in figure 1), achieving UWB over 2.12GHz-14.44GHz with a bandwidth 12.32GHz. Figure 3 shows the impedance reflection coefficient characteristics and figure 4 shows the VSWR for the initial design.

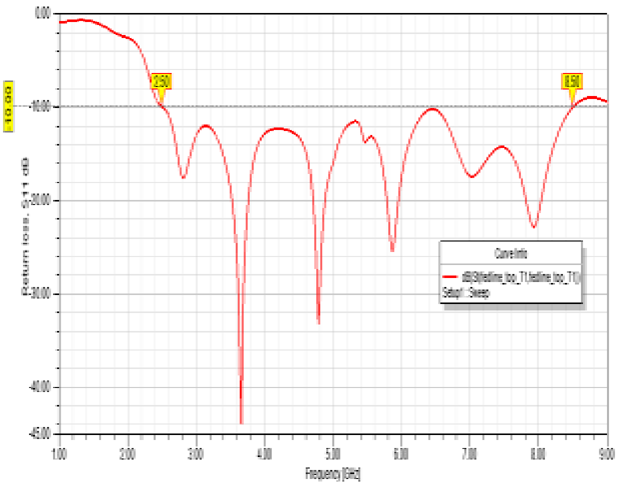

Fig-3: Return loss characteristics for initial design

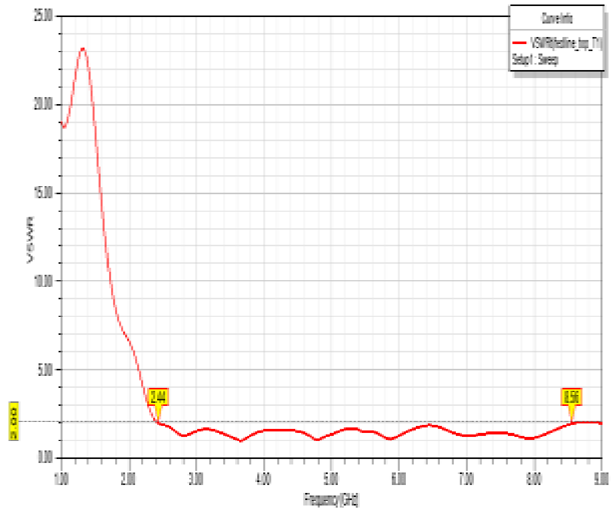

Fig-4: VSWR for initial design

Figure 5 shows the return loss characteristics of proposed design.The self-complimentary structure is etched in the ground to enhance the bandwidth and gain characteristics. Figure 6 shows the VSWR of the proposed design.

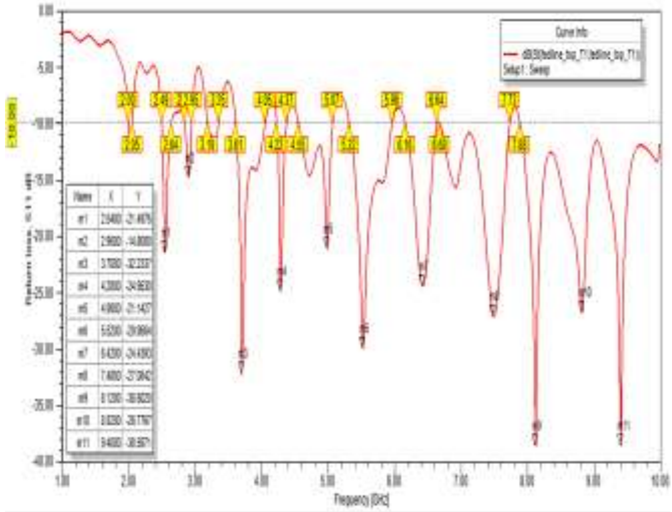

Fig-5: Return loss characteristics of the proposed antenna design

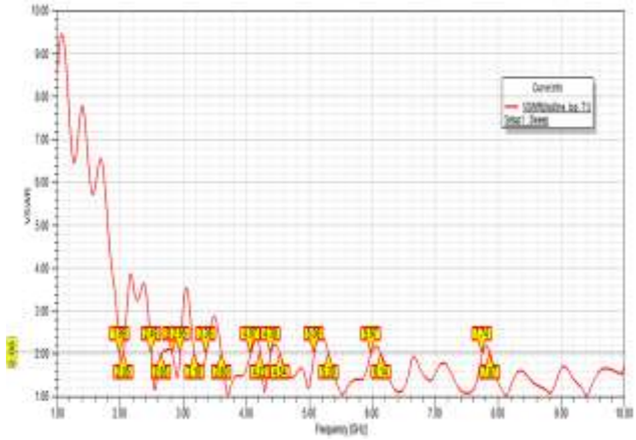

Fig-6: VSWR of the proposed antenna design

The impedance bandwidths of the proposed antenna design are 150MHz(2.49-2.64GHz), 90MHz(2.84-2.95GHz), 440MHz(3.61-4.05GHz), 150MHz(4.22-4.37GHz), 520MHz(4.55-5.07GHz), 640MHz(5.32-5.96GHz), 480MHz(6.16-6.64GHz)at their resonant frequencies are 2.54GHz, 2.90GHz, 3.70GHz, 4.28GHz, 4.98GHz, 5.52GHz, 6.42GHz and 7.48GHz with reflection coefficients -21.49dB, -14.80dB, -32.23dB, -24.95dB, -21.14dB, -29.95dB, -24.43dB and -27.08dB respectively and also one broad band with resonances at 8.12GHz, 8.82GHz, 9.40GHz with -38.60dB, -26.77dB, -38.59dB respectively.

3.2 Far Field Characteristics

The corresponding peak gains of the proposed antenna are 0.05dB, 0.66dB, 1.07dB, 1.54dB, 1.87dB, 2.96dB, 3.46dB, 4.10dB, 3.30dB, 3.43dB and 2.81dB at their corresponding resonant frequencies 2.54GHz, 2.90GHz, 3.70GHz,4.28GHz, 4.98GHz, 5.52GHz, 6.42GHz 7.48GHz, 8.12GHz, 8.82GHz and 9.40GHz respectively. The direction of 3D gain plots are shown in figure 7.

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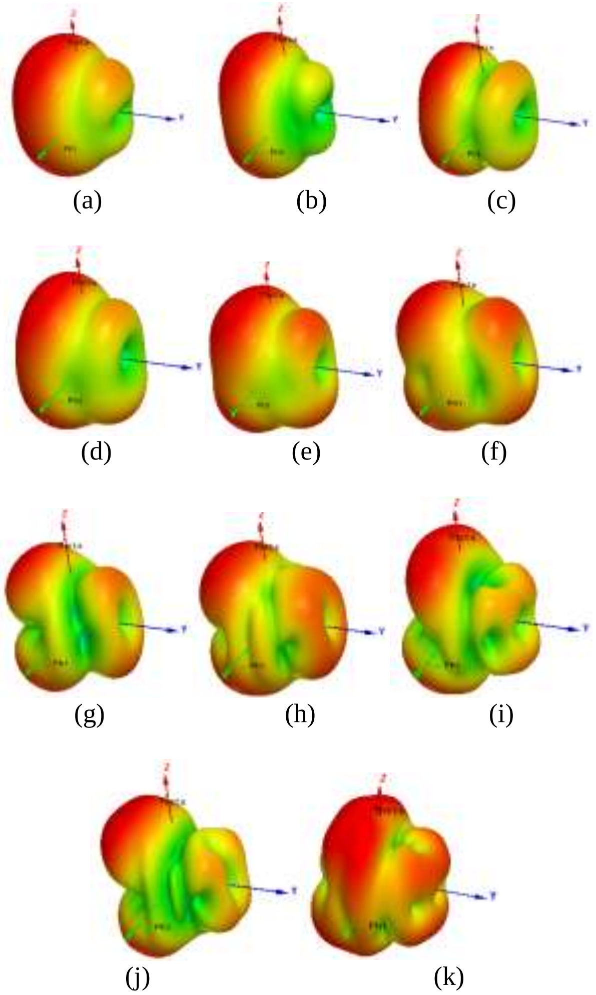
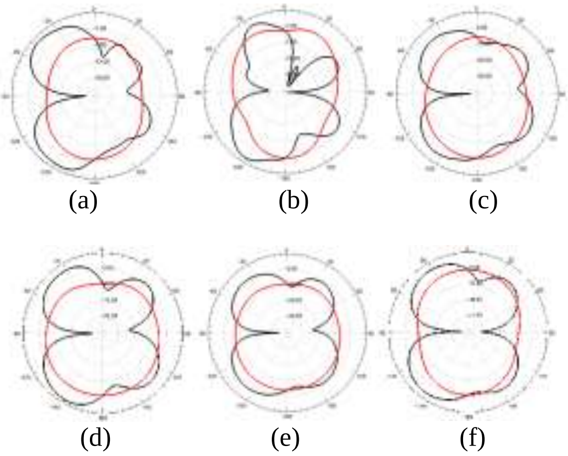


Fig-7: Simulated 3D gain polar plots of the proposed antenna at a) 2.54GHz, b) 2.90GHz, c) 3.70GHz, d) 4.28GHz, e) 4.98GHz, f) 5.52GHz, g) 6.42GHz, h) 7.48GHz, i) 8.12GHz, j) 8.82GHz, k) 9.40GHz

The radiation patterns for both E-plane and H-plane at their resonant frequencies are shown in figure 8.



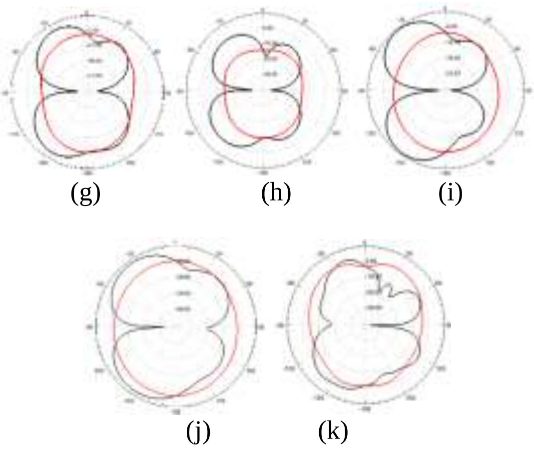
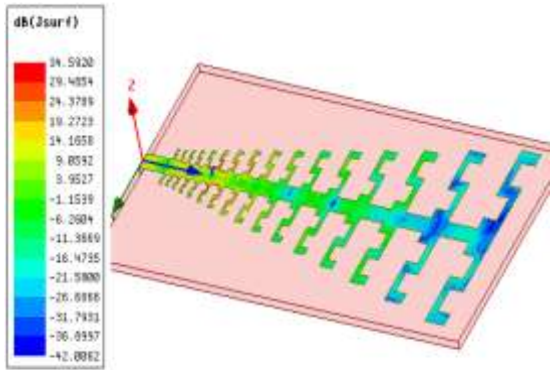


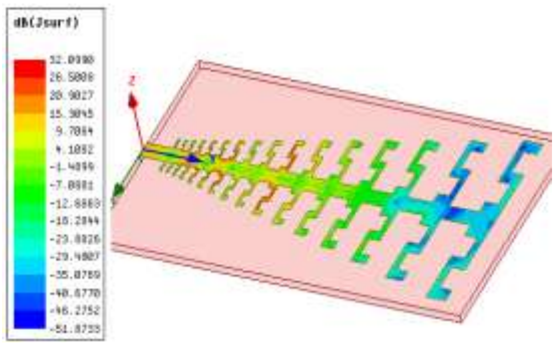
Fig-8:simulated radiation patterns of the proposed antenna at a) 2.54GHz, b) 2.90GHz, c) 3.70GHz, d) 4.28GHz, e) 4.98GHz, f) 5.52GHz, g) 6.42GHz, h) 7.48GHz, i) 8.12GHz, j) 8.82GHz, k) 9.40GHz (red-elevation plane, black-azimuth plane)

3.3 Surface Current Distribution

For more understanding the role of dipole elements in improving the antenna gain and bandwidth, the magnitude surface current distribution inside the dipole elements is shown in figure 9. At higher frequencies, smaller elements are radiated and at low frequencies, larger elements are radiated. The modified element compared with the dipole element, there are more discontinuous on the dipole due to this current flow increases in the proposed design. So, radiation efficiency has been improved.



(a)



(b)

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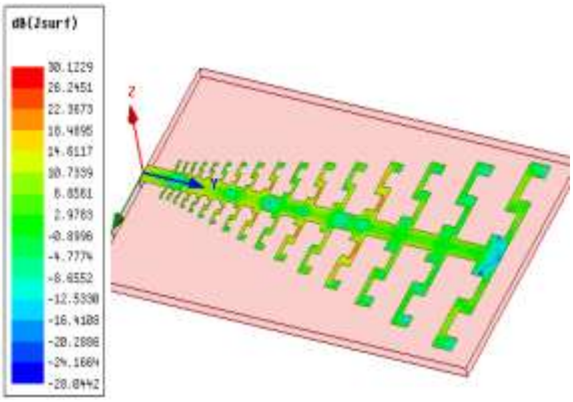
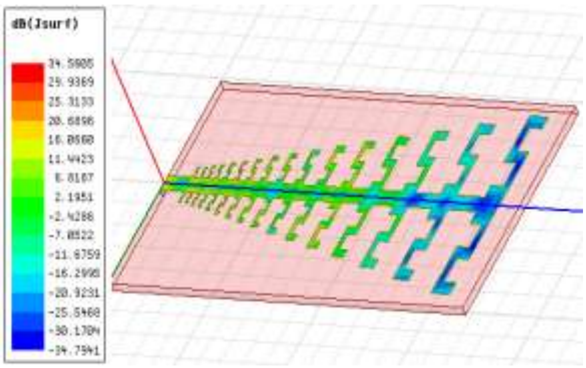


(c)



(d)

Fig-9: Surface current distribution at a) 3.70GHz b) 5.52GHz c) 7.48GHz d) 9.40GHz

4. CONCLUSION

The log periodic S-shape fractal dipole antenna for multiband characteristics was proposed with simulated results. The fractal implemented for LPDA to gain miniaturization in size, enhanced the bandwidth and improved the number of resonant frequency bands. The characteristics of antenna such as return loss, VSWR and far-field radiation characteristics have been simulated at resonant frequencies.The radiation efficiency of the proposed antenna has been improved from the magnitude surface current distribution of the structure. The proposed antenna operates at 2.54GHz, 2.90GHz, 3.70GHz, 4.28GHz, 4.98GHz, 5.52GHz, 6.42GHz, 7.48GHz, 8.12GHz, 8.82GHz and 9.40GHz with better impedance matching. Hence, the proposed antenna is most suitable for multiband characteristics of antenna and used for various applications like PCS, DCS, WiFi, WLAN, WiMAX, S- & C-band applications.

REFERENCES

[1] Carrel, R., "The design of log-periodic dipole antennas," IRE International ConventionRecord, Vol. 9, 61-75, 1961.

[2] Isbell, D. E., "Log periodic dipole arrays," IEEE Transactions on Antennas andPropagation, Vol. 8, 260-267, 1960.

[3] Carrel, R.,Analysis and design of the log-periodic dipole antenna," Ph.D. Dissertation,University of Illinois, 1961.

[4] Giovanni A.Casula, Paolo Maxia, Giuseppe Mazzarella, Giorgio Montisci, "Design of APrinted Log-Periodic Dipole Array for Ultra-Wide Band Applications", PIERS C, vol.38,15-26, 2013.

[5] M.I.Mirzapour, S.M.J.Razavi and S.H.MohseniArmaki, "Ultra-wideband planar LPDAantenna with mode converter balun", IEEE, 5th June 2014, vol.50, No.12, pp 848-850.

[6] Zhenxin Hu, ZhongxiangShen, Wen Wu, Jian Lu, "Low-profile Log-periodic monopolearray", IEEE transactions on Antennas and propagation, vol.63, No.12, Dec15.

[7] Chun-Te Wu, Wei-Zhe Dai, Cheng-Nan Chiu, Han-Chang Hsieh, "BandwidthEnhancement of Micro strip Fed Koch Snowflake Fractal Slot Antenna", APEMC2015.

[8] DimitrisE.Anagnostou, John Papapolymerou, Manos M.Tentzeris, ChristosG.Christodoulou, "A Printed Log-Periodic Koch Dipole Array [LPKDA]", IEEEAntennas and Wireless Propagation Letters, vol.7, 2008.

[9] M.N.A.Karim, M.K.A.Rahim,H.A.Majid, O.Ayop, M.Abu, F.Zubir, "Log PeriodicFractal Koch Antenna forUHF Band Applications", PIER 100, 201-218, 2010.

[10] RuiXu, Jian-Ying Li, Jiang-Jun Yang, Kun Wei, Yang-Xiao Qi, "A Design of U-ShapesSlot Antenna with Broadband Dual Circularly Polarized Radiation", IEEE Transactionson Antennas And Propagation, 2017.

[11] Elena Abdo-Sanchez, Jaime Esteban, Teresa M.Martin- Guerreto, Carloy Camacho-Penelosa, Peter S.Hall, "A Novel Planar Log-Periodic Array Based On The WidebandComplementary Strip-slot Element", IEEE Transactions on Antennas and Propagation,vol.62, No.11, Nov 2014.

[12] HomayoonOraizi, ShahramHedayati, "Miniaturization of Micro strip Antennas by theNovel Application of the Giuseppe Peano Fractal Geometries", IEEE Transactions onAntennas and Propagation, vol.60, No.8, August2012.

BIOGRAPHIES

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