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# A Dielectric Resonator Loaded Fractal Shaped Slot Loop multiband Antenna

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*Abstract*— **A multiband fractal coplanar waveguide (CPW)-fed slot antenna loaded with a dielectric resonator conforming to multiple wireless standards is presented in this paper. The fractal geometry is utilized to generate multiple frequency bands. The dielectric load is used to enhancing the impedance bandwidth of the antenna and improving the overall gain of the antenna. The proposed antenna exhibits a multiband performance.**

Keywords— **Fractal antenna, Dielectric loading, multi-frequency antenna, slot antenna.**

## I. INTRODUCTION

Mobile communication system demand increased bandwidth for data and voice applications. Also with most systems supporting multiple wireless standards, Multiband antennas cater to these needs by radiating at discrete frequencies only. THE primary design constraints of such antennas include maintaining gain and radiation pattern over different frequencies. The most of the research papers have been focused on designing multiband antennas [1]– [10] of which the most popular technique is etching slots on the radiating patch or the ground plane. 1]–[3]. Care has to be taken while etching slots on the patch as it reduce the effective radiation aperture resulting in lower gain values The primary intention of this work was to design a multiband antenna for multiple wireless standards. Fractal antennas, however, reduces the overall size of the antenna and producing multiple resonant bands. The disadvantage of etching multiple slots on a patch antenna is that it reduces the overall gain of the antenna because major portion of the antenna are etched out. The principal idea behind reduction in resonant frequency lies in the increase of the current path due to the fractal design of the structure.

A fractal shaped CPW fed slot loop antenna has been designed to cover five different wireless standards among others. However, it is difficult to maintain the gain of the antenna at a near constant value over different frequencies. To overcome this, the slot antenna is loaded with a square-shaped dielectric resonator (DR) to obtain almost constant gain at all discrete frequencies. This antenna conforms to Global System for Mobile Communications (GSM) 900 (890–960 MHz), Personal Communications Service (PCS) 1900 (1850–1990 MHz), WiMAX 3.5 (3.4–3.6 GHz), IEEE 802.11b/g/n (2.4–2.485 GHz), and IEEE 802.11a/h/j/n (5.15–5.85 GHz) among others. An equivalent model of the antenna is provided

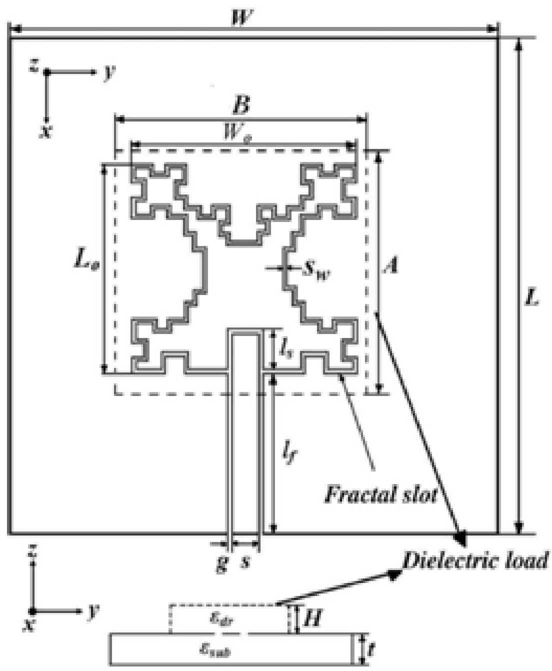


Fig. 1. Layout of the fractal slot antenna with dielectric loading.

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## II. Antenna Design Procedure and Parametric Study

The antenna design has been undertaken in two steps. In the first part, a rectangular loop slot fed by a coplanar waveguide was designed and fractal geometry applied on its boundaries to obtain multiple bands [16]. Fig. 1 shows the configuration of the fractal loop antenna which has been etched on an FR4 substrate with thickness $t = 1.6$ mm relative permittivity $\varepsilon_{sub} = 4.4$ and having dimensions $L \times W = 100$ mm $\times$ $100$ mm. The 50-Ω coplanar waveguide feed line is designed to have a central conductor width of $s = 4.2$ mm and a gap width of $g = 0.4$ mm. Considering a frequency of operation of 2.4 GHz applying the formula

$$\lambda_g = \frac{c}{f\sqrt{\epsilon_r}}$$

where $\lambda g$ is the guided wave-length, $c$ is the speed of light in vacuum, $f$ is the operation frequency, and $\varepsilon e$ is the effective permittivity of the slot line [17]. it is observed that a second-order fractal is sufficient to meet the application requirements. The generation of the fractal is shown in Fig. 2 [18]. The fractal design is formed by shifting the middle one-third of each straight segment (indentation length) by some fraction value called the indentation width. Indentation factor $i$ is defined as the ratio of indentation width to the indentation length.

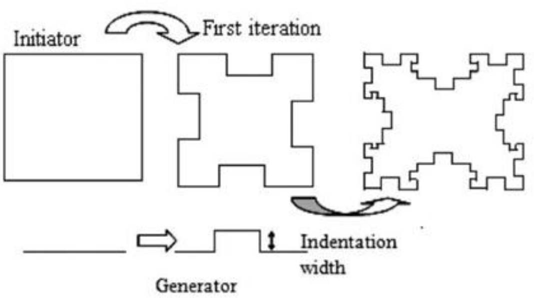


Fig.2. Generation of fractal island

Design parameters and corresponding values

TABLE I

| PARAMETER | VALUES |
|---|---|
| Ground plane size **(L*W)** | 100mm*100mm |
| Loop Slot Dimension **($L_o$*$W_o$)** | 25mm*25mm |
| Stub length **($L_s$)** | 3mm |
| Slot width **($S_w$)** | 0.4mm |
| 1st indentation factor **($i_1$)** | 0.9 |
| 2nd indentation factor **($i_2$)** | 0.5 |
| Dielectric Slab Dimensions (A*B*H) | 33mm*30mm*5mm |

**Fractal antenna designed with first iteration:**

Antenna is designed with first iteration and results plotted between reflection coefficient and frequency.

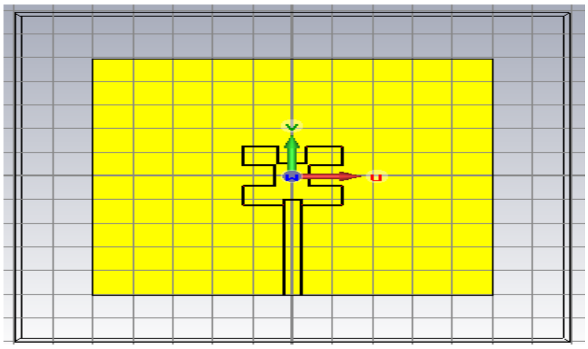

Fig.3. antenna designed with first iteration

The fractal antenna designed by using indentation factor 0.9 as shown in fig.3.

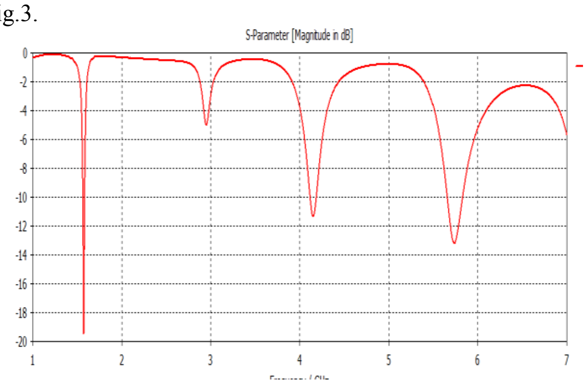


Fig.4. s-parameter plot after first iteration

After first iteration design, the antenna radiates at frequency 1.6Ghz,4.2Ghz and 5.6Ghz as shown in fig.4. where three frequencies at $S_{11} < -10$.

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**Fractal antenna designed with 2nd iteration:**

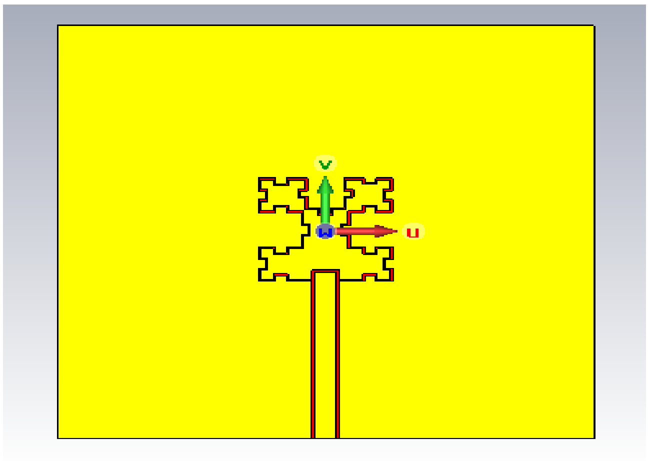



Fig.5.Fractal antenna designed with second iteration

The fractal antenna designed by using indentation factor 0.5 as shown in fig.5.

S-PARAMETER AND VSWR PLOT

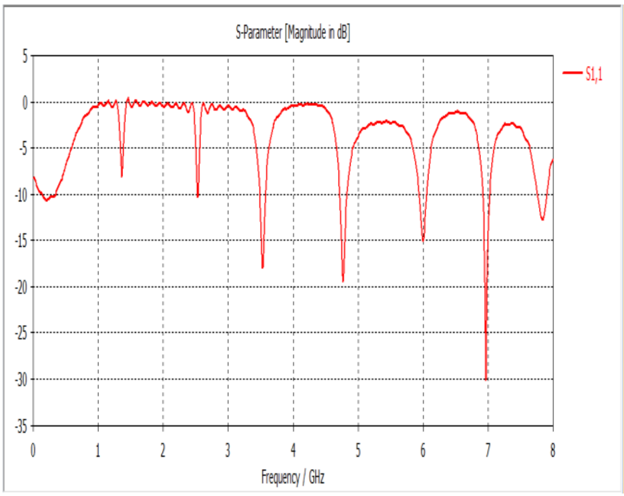



Fig.6.s-parameter plot after second iteration without dielectric resonator loaded

After second iteration design, the antenna radiates at frequency 2.4Ghz,3.5Ghz,4.8Ghz, 6Ghz and 6.9Ghz as shown in Fig.6. where $S_{11}$< -10.

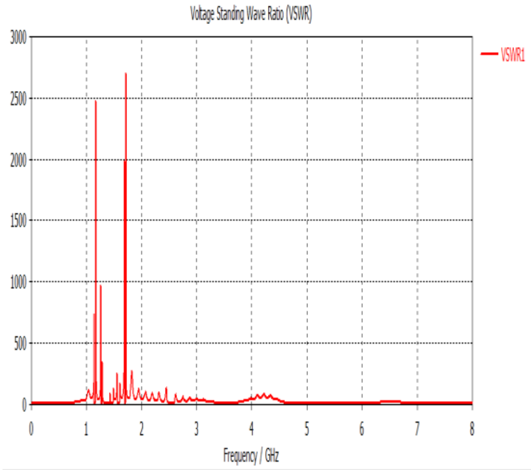



Fig.7.VSWR PLOT

VSWR(voltage standing wave ratio) is the ratio of maximum amplitude of a standing wave to the minimum amplitude of a standing wave.

DIELECTRIC RESONATOR LOADED ANTENNA

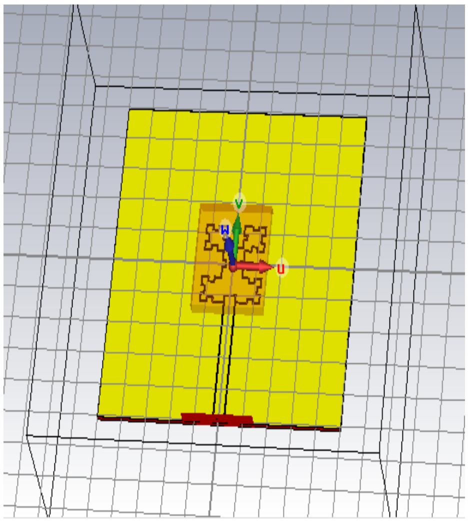



Fig.8. dielectric resonator loaded antenna

In the above fig.8 ,after second iteration the dielectric resonator loaded on the antenna

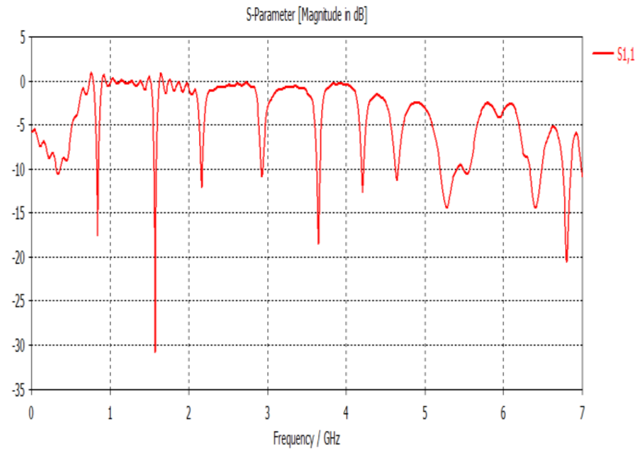
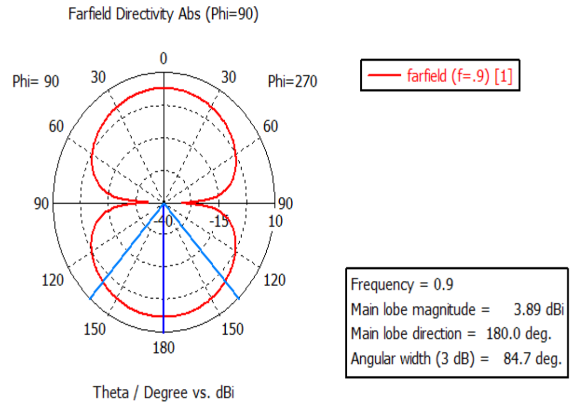
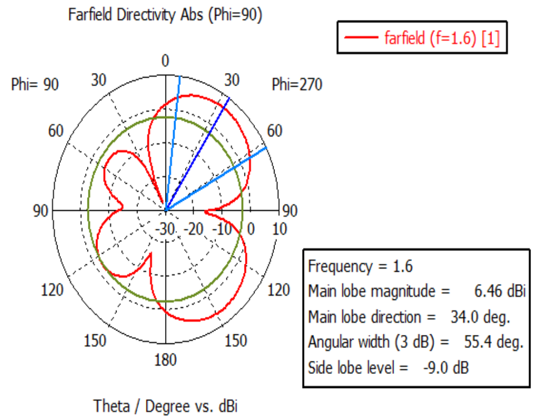



Fig.9. S-parameter plot with dielectric resonator loaded

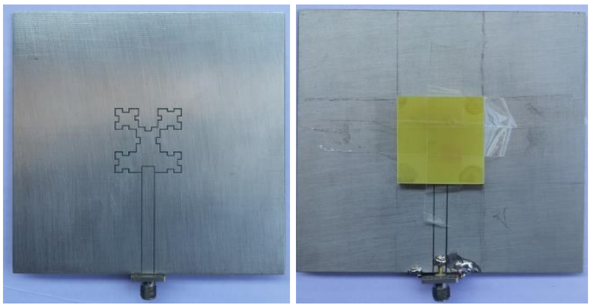



(a)

When dielectric resonator loaded , the antenna radiates at frequency 0.9Ghz,1.6Ghz,2.2Ghz,2.9Ghz,3.65Ghz,4.8Ghz, 6Ghz and 6.9Ghz as shown in Fig.6.,where $S_{11}$< -10dB. A wave experiences partial transmittance and partial reflectance when the medium through which it travels suddenly changes. The reflection coefficient determines the ratio of the reflected wave amplitude to the incident wave amplitude.




(b)



Photograph of the designed antenna (a) Fractal slot loop antenna and (b) dielectric loaded fractal slot loop antenna

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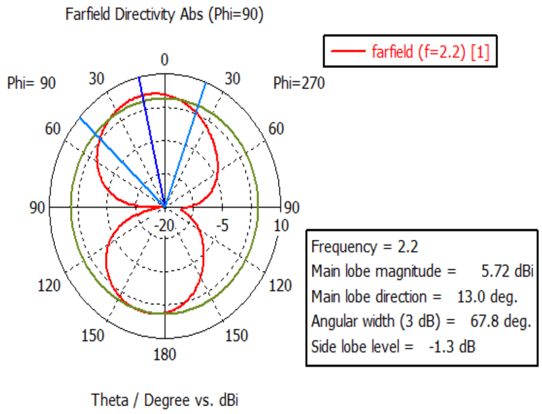
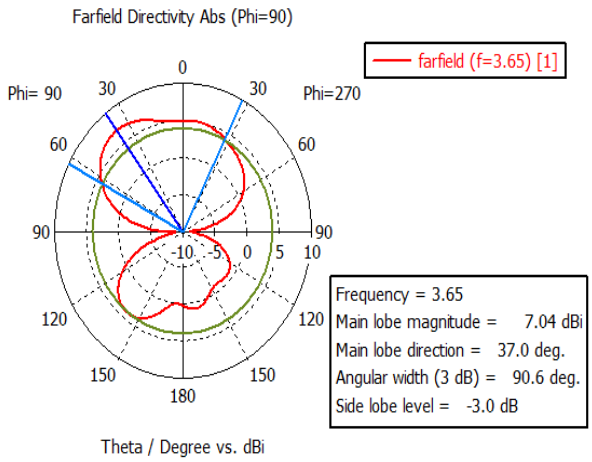
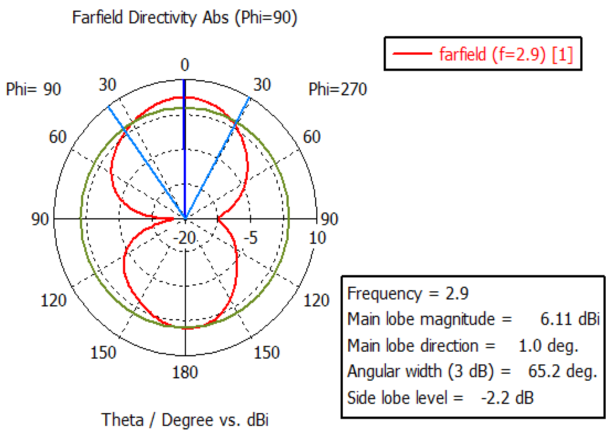


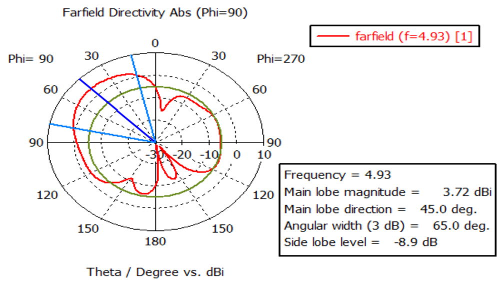

(c)



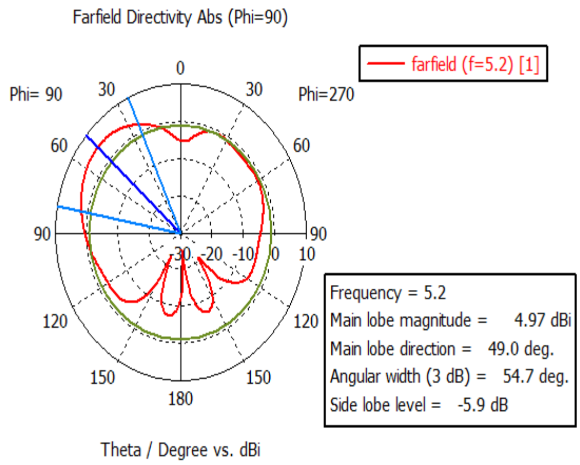

(e)



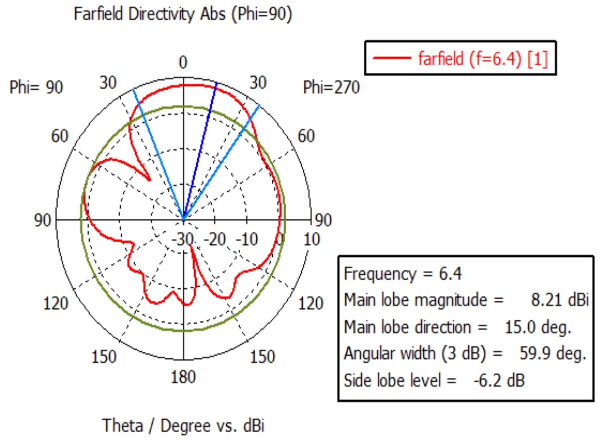

(d)



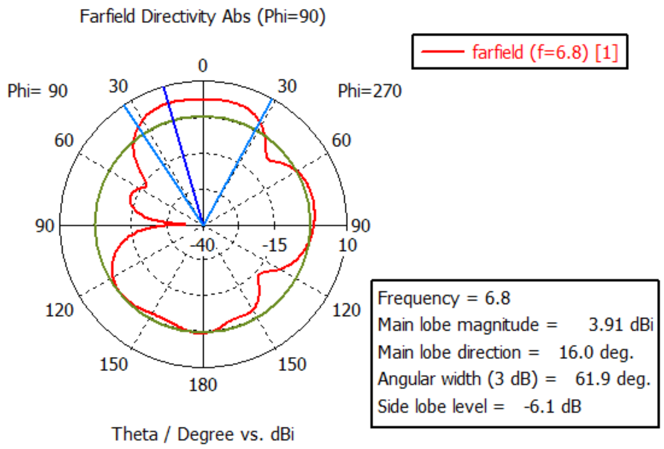

(f)




(g)




(h)




(i)

The Simulated radiation patterns at (a) 0.95 GHz; (b) 1.6 GHz; (c) 2.2 GHz; (d)2.9 GHz; (e)3.65 GHz; (f)4.93 GHz (g)5.2 GHz (h)6.4Ghz (i)6.8Ghz

TABLE II

| FREQUENCY(GHz) | GAIN(dBi) | DIRECTIVITY(dBi) |
|---|---|---|
| 0.9 | 3.89 | 3.894 |
| 1.6 | 6.46 | 6.456 |
| 2.2 | 5.72 | 5.718 |
| 2.9 | 6.11 | 6.108 |
| 3.65 | 7.04 | 7.018 |
| 4.93 | 3.72 | 6.25 |
| 5.2 | 4.97 | 5.796 |
| 6.4 | 8.21 | 8.213 |
| 6.8 | 3.91 | 6.525 |

## V. MEASURED RESULTS AND DISCUSSION

All S-parameters are measured using network analyzer. Sufficient gain is achieved in 0.9GHz, 1.6 GHz (GPS), 2.2Ghz (IEEE 802.11b/g/n),2.9GHz, 3.6GHz(Wi-Max), 4.93 GHz, 5.2GHz, 6.4GHz, 6.8GHz bands as shown in TABLE II. The simulated s-parameter results of the dielectric loaded fractal slot loop antenna is shown in Fig. 9.

## VI. CONCLUSION

The dielectric loaded fractal slot loop antenna is used for multiband performance in this paper. Fractal boundary slot etched on an FR4 substrate fed by Co-planar waveguide. The fabricated fractal antenna yields a multiband performance for a −10 dB reflection coefficient. The overall directivity improved by placing the dielectric slab on top of the slot antenna.

## REFERENCES


[1] C. C. Chen, C. Y. D. Sim, and F. S. Chen, "A novel compact quad-band narrow strip-loaded printed monopole antenna," *IEEE Antennas Wireless Propag. Lett.*, vol. 8, pp. 974–976, Aug. 2009.

[2] R. A. Bhatti, Y. T. Im, and S. O. Park, "Compact PIFA for mobile termi-nals supporting multiple cellular and non-cellular standards," *IEEE Trans. Antennas Propag.*, vol. 57, no. 9, pp. 2534–2540, Sep. 2009.

[3] Y. Cao, B. Yuan, and G. Wang, "A compact multiband open-ended slot antenna for mobile handsets," *IEEE Antennas Wireless Propag. Lett.*, vol. 10, pp. 911–914, Sep. 2011.

[4] S. I. Latif and L. Shafai, "Investigation on the EM-coupled stacked square ring antennas with ultra-thin spacing," *IEEE Trans. Antennas Propag.*, vol. 59, no. 11, pp. 3978–3990, Nov. 2011.

[5] K. Huang and T. Chiu, "Triband inverted-F antenna with stacked branched monopoles and a parasitic strip," *IEEE Antennas Wireless Propag. Lett.*, vol. 10, pp. 1208–1211, Nov. 2011.

[6] O. P. Falade, M. U. Rehman, Y. Guo, X. Chen, and C. G. Parini, "Single feed stacked patch circular polarized antenna for triple band GPS receivers," *IEEE Trans. Antennas Propag.*, vol. 60, no. 10, pp. 4479–4484, Oct. 2012.

[7] F. J. H. Martinez, G. Zamora, F. Paredes, F. Martin, and J. Bonache, "Multiband printed monopole antennas loaded with OCSRRs for PANs and WLANs," *IEEE Antennas Wireless Propag. Lett.*, vol. 10, pp. 1528– 1531, Dec. 2011.

[8] M. R. Booket *et al.*, "Compact multi-band printed dipole antenna loaded with single-cell metamaterial," *IET Microw. Antennas Propag.*, vol. 6, no. 1, pp. 17–23, Mar. 2012.

[9] K. C. Lin, C. H. Lin, and Y. C. Lin, "Simple printed multiband antenna with novel parasitic-element design for multistandard mobile phone applications," *IEEE Trans. Antennas Propag.*, vol. 61, no. 1, pp. 488–491, Jan. 2013.

[10] C. T. P. Song, P. S. Hall, and H. G. Shiraz, "Shorted fractal sierpin-ski monopole antenna," *IEEE Trans. Antennas Propag.*, vol. 52, no. 10, pp. 2564–2570, Oct. 2004.

[11] D. D. Krishna, M. Gopikrishna, C. K. Anandan, P. Mohanan, and K. Vasudevan, "CPW-fed koch fractal slot antenna for WLAN/WiMAX applications," *IEEE Antennas Wireless Propag. Lett.*, vol. 7, pp. 389–392, Nov. 2008.

[12] C. Varadhan *et al.*, "Triband antenna structures for RFID systems deploy-ing fractal geometry," *IEEE Antennas Wireless Propag. Lett.*, vol. 12, pp. 437–440, Mar. 2013.

[13] S. Dhar, R. Ghatak, B. Gupta, and D.R. Poddar, "A wideband Minkowski fractal dielectric resonator antenna," *IEEE Trans. Antennas Propag.*, vol. 61, no. 6, pp. 2895–2903, Jun. 2013.

[14] Y. Gao, B. L. Ooi, and A. P. Popov, "Dual-band hybrid dielectric res-onator antenna with CPW-fed slot," *Microw. Opt. Technol. Lett.*, vol. 44, no. 1, pp. 170–172, Jan. 2006.

[15] Y. F. Lin, H. M. Chen, and C. H. Lin, "Compact dual-band hybrid dielectric resonator antenna with radiating slot," *IEEE Antennas Wireless Propag. Lett.*, vol. 8, pp. 6–9, Mar. 2009.

[16] S. Dhar, S. Maity, B. Gupta, D. R. Poddar, and R. Ghatak, "A CPW fed slot loop minkowski fractal antenna with enhanced channel selectivity," in *Proc. Int. Conf. Commun. Devices Intell. Syst.*, 2012, pp. 542–545.

[17] K. C. Gupta, R. Garg, I. Bahl, and P. Bhartia, *Microstrip Lines and Slot Lines.* Norwood, MA, USA: Artech House, 1996, pp. 282–286.

[18] J. P. Gianvittorio and Y. R. Samii, "Fractal antennas: A novel antenna miniaturization technique, and applications," *IEEE Antennas. Propag. Mag.*, vol. 44, no. 1, pp. 20–36, 2002.

[19] K. M. Luk and K. W. Leung, *Dielectric Resonator Antennas*. Hertfordshire, England: Research Studies Press Ltd., 2003, pp. 55–92.

[20] T.-G. Ma, R.-C. Hua, and C.-F. Chou, "Design of a multiresonator loaded band-rejected ultrawideband planar monopole antenna with controllable notched bandwidth," *IEEE Trans. Antennas Propag.*, vol. 61, no. 6, pp. 2875–2883, Sep. 2008.

[21] S.-J. Wu and J.-H. Tarng, "Planar band-notched ultra-wideband antenna with square-looped and end-coupled resonator," *IET Microw. Antennas Propag.*, vol. 5, no. 10, pp. 1227–1233, 2011.

[22] A. A. Kishk, X. Zhang, A. W. Glisson, and D. Kajfez, "Numerical analysis of stacked dielectric resonator antennas by a coaxial probe for wideband applications," *IEEE Trans. Antennas Propag.*, vol. 51, no. 8, pp. 1996–2006, Aug. 2003.

[23] D. R. Jackson and N. G. Alexopoulos, "Fundamental superstrate (cover) effects on printed circuit antennas," *IEEE Trans. Antennas Propag.*, vol. 32, no. 9, pp. 807–816, Aug. 1984.