ISSN 2278-3091
Volume 8, No.4, July – August 2019
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse94842019.pdf
https://doi.org/10.30534/ijatcse/2019/94842019

Design of a Koch Shaped Fractal Antenna for Wireless Applications

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ABSTRACT

A Koch shaped fractal antenna (FA) is simulated and analyzed for wideband frequencies in this paper. The triangular shape is used for designing Koch fractal. The Koch shaped FA antenna is designed using commercially available Computer Simulation Technology (CST) microwave studio suite. The overall size of the proposed FA is 29 x 47 x 1 mm^3. The substrate material used for the design Koch FA is Rogers RT 5880 with $\varepsilon_r = 2.2$ and tan $\delta = 0.02$. The proposed Koch FA operating range is from 2.89 GHz to 7.09 GHz with a bandwidth of 4.2 GHz. The proposed model covers the WiMAX/WLAN, 3G, 4G and some of UWB bands.

Key words: Koch Fractal, WLAN, Wi-Max, Fractal Antenna (FA), DGS Ground Plane.

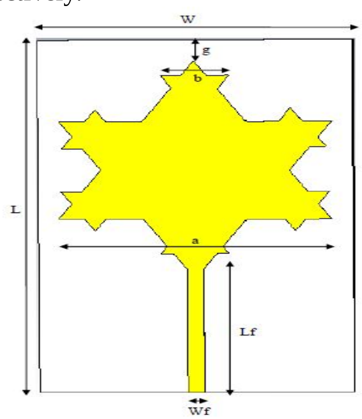
1. INTRODUCTION

Wideband antennas are gaining massive popularity in wireless communications. The conventional patch antennas are mainly suffering from narrow bandwidth [1]. A fractal shaped antenna for wideband operating frequencies is used to overcome problems with narrow bandwidth antennas. Different Monopole fractal shaped antenna having excellent reflection characteristics with wide bandwidth [2]. Due to the advancements in design and fabrication technologies, the performance of patch antennas has enhanced while making feasible to use in WLAN and Wi-Max applications operating at the range of 2 to 7 GHz [3-4].

To improve the bandwidth in ultra-wideband antenna, the multi-resonant structure of hexagonal radiator with six hexagonal patches added at the edges of the patch [5-6]. Any complicated structure of FA's replaced with simple H shaped FA applicable to multiband operating frequencies in [7-8]. The ground plane modified with sierpinski gasket repeated with some inclination proposed in [9-10] for getting dual-band operating frequencies. A slotted ground plane with triangular slot FA is designed and analyzed in this work. The proposed model gives the impedance bandwidth of 4.2 GHz and gives stable radiation characteristics throughout the operating band.

2. FRACTAL ANTENNA DESIGN

In the present paper, the design consists of the fractal shaped equilateral triangular and inverted equilateral triangular patch shapes taken as a proposed design shown in Figure 1, and the fractal shape patch and ground are shown in Figure 1 (a) and (b). The substrate used for design FA is RT5880 with $\varepsilon_r = 2.2$, tan $\delta = 0.02$ and the height (h) of the substrate is 1mm. The overall size of the fractal antenna is 29 x 47 mm^2. The DGS based ground used as the base of the antenna, DGS is used to improve the impedance characteristics of adjacent resonant frequencies. The FA designed by adding a small triangular block at the end of inverted triangles. The dimensions of the FA are represented in Table 1. The commercially available FDTD based CST microwave studio software is used for design, simulation and analysis of proposed FA. The simulation results of fractal shape rectangular patch antenna give the return loss (S11) < -10 dB from 2.89 GHz to 7.09 GHz and corresponding VSWR from 2.89 GHz to 7.09 GHz is less than 2 are shown in Figure 1 (c) and (d) respectively.



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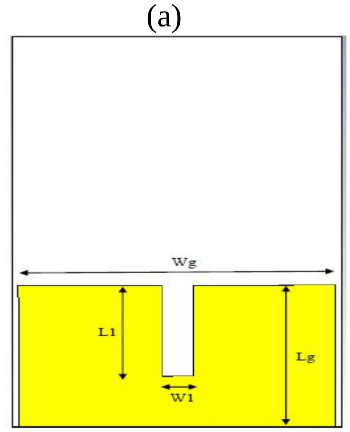

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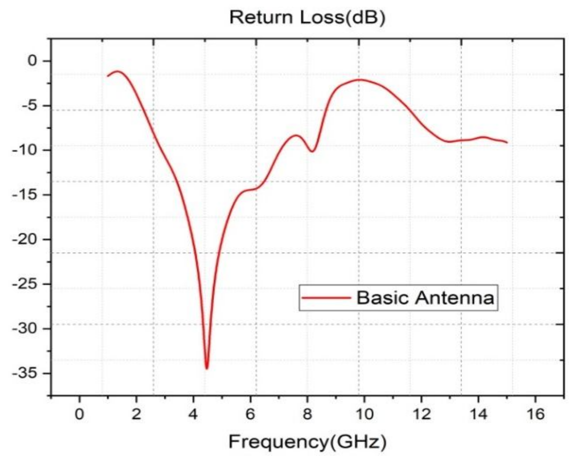

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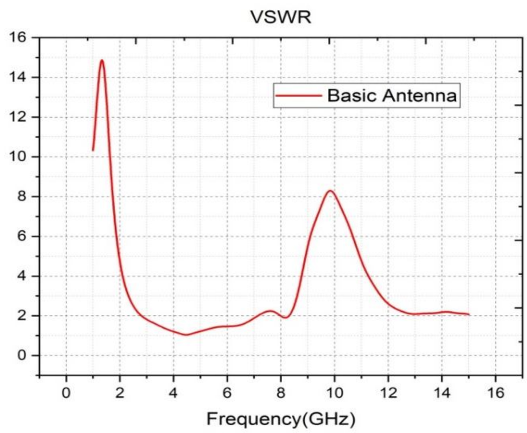


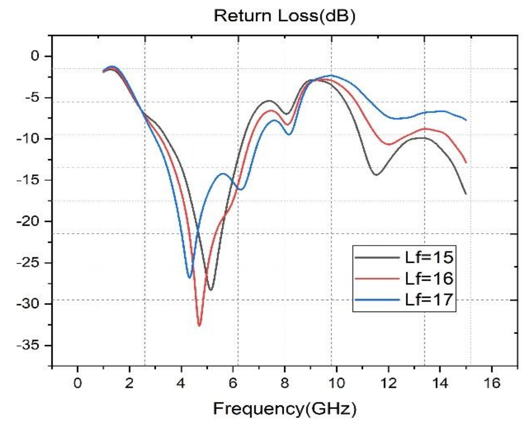
(d)

Figure 1: (a) Koch fractal patch (b) Ground plane (c) S11 (d)VSWR parameter of basic Koch FR

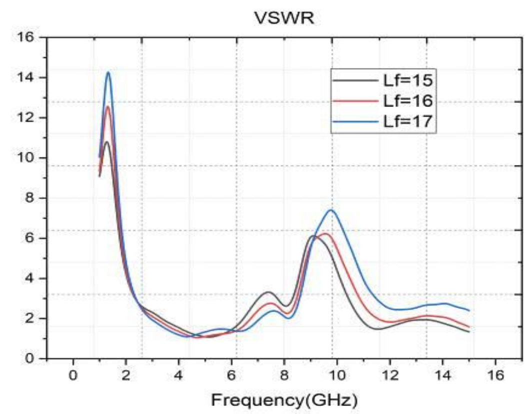
Table 1: Measurements of the proposed FA

Parameter	Measurements (mm)
L	47
W_s	29
L_g	28
W_g	17
A	24
G	2.91
W_1	2.5
L_1	11
L_f	17
W_f	1.5
b	6

Figure 2 (a) & (b) represents the return loss and VSWR of simulation results of varying feed length (L_f) parameter. By modifying the L_f from 15 mm to 17 mm with an increment of 1 mm, the bandwidth of the antenna changing from 2.5 GHz to 4.02 GHz. The optimized valued for the Koch fractal length of the feed is 17 mm. The fractal antenna is covering the two frequencies of WLAN and Wi-Max ranges. The proposed FA gives good agreement in terms of all the simulation parameters.



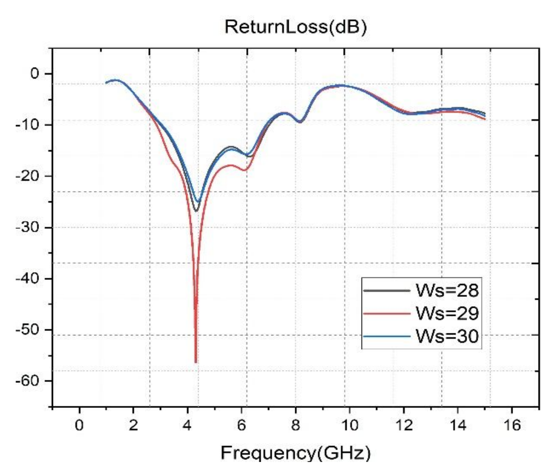
(a)



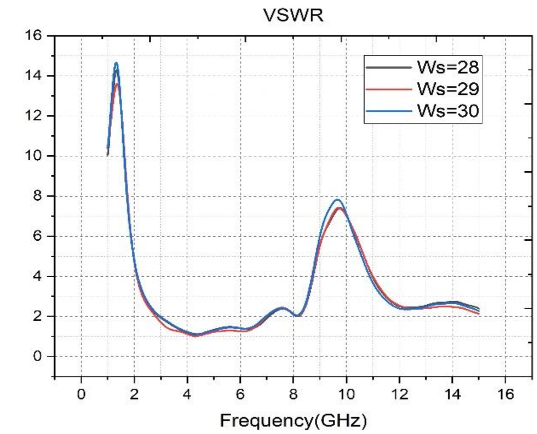
(b)

Figure 2: (a) S11 (b) VSWR of feed length

The comparison results of return loss and VSWR are represented in figure 3. By varying the width of the substrate (W_s) and by keeping all other parameters are constant. The W_s is ranging from 28 mm to 30 mm with an incremental value of 1 mm. The optimal value chosen for the W_s parameter is 29 mm. The optimized parameter values are selected according to the bandwidth parameter.



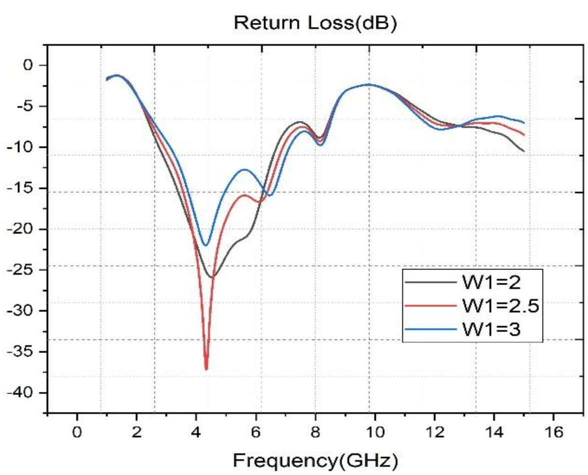
(a)



(b)

Figure 3: (a) S11 (b) VSWR width of the substrate

Figure 4 (a) & (b) represents the return loss and VSWR of simulation results of varying ground slot width (W1) parameter. By modifying the W1 from 2 mm to 3 mm increment of 0.5 mm the bandwidth of the proposed antenna is varying from 3.2 GHz to 4.02 GHz. The optimized valued for the Koch fractal ground slot is 2.5 mm. The fractal antenna is covering the two bands of WLAN and Wi-Max.



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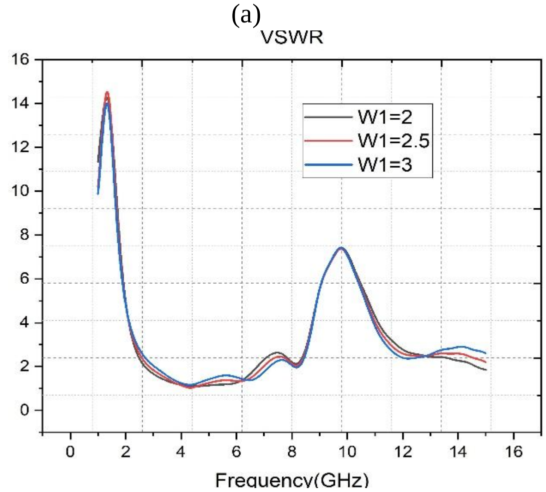
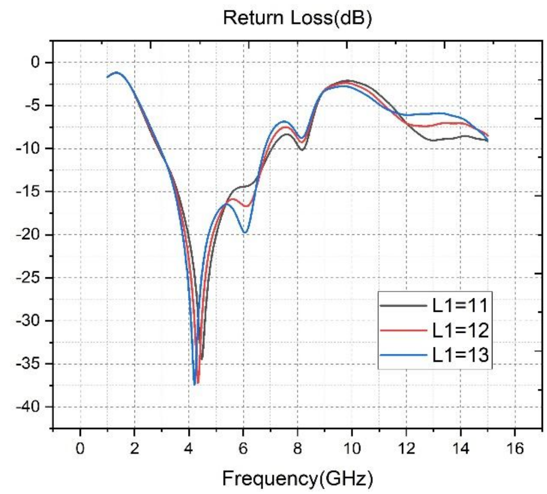


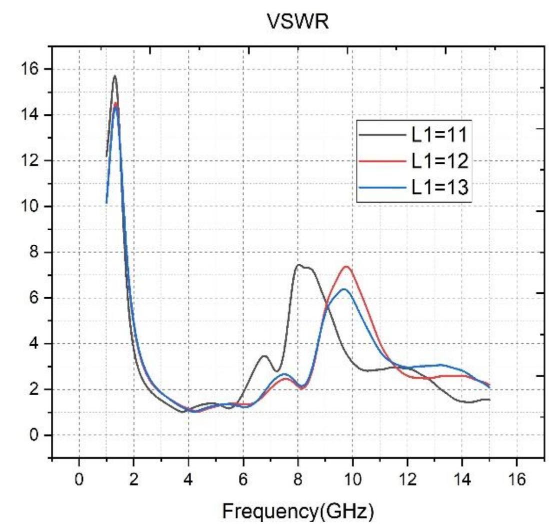
(b)

Figure 4: (a) S11 (b) VSWR of slot width

The parameter comparison results of return loss and VSWR are represented in figure 5. By varying the ground slot length (L1) by keeping all other parameters are constant. The L1 is ranging from 11 mm to 13 mm with an incremental value of 1 mm. The optimal value chosen for the L1 is 12 mm. The optimized parameter values are selected according to the bandwidth parameter.



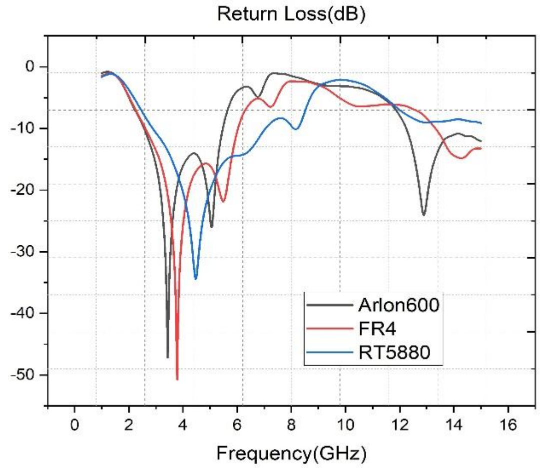
(a)



(b)

Figure 5: (a) S11 (b) VSWR of Slot Length

Figure 6 (a) and (b) is the comparison result of return loss and VSWR of different substrate materials. The substrates used for the optimizing purpose are Arlon600, FR4 and RT5880 with different dielectric constants and thickness. The best suitable material for getting good bandwidth and gain is RT duroid 5880 with $\varepsilon_r = 2.2$.



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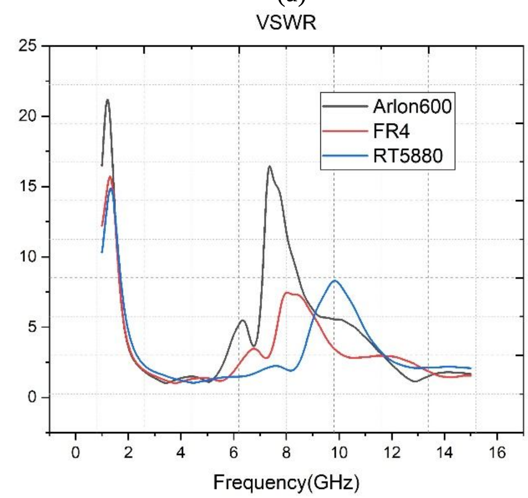
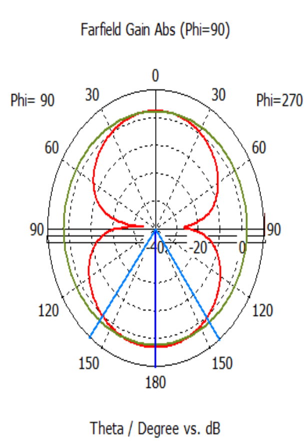


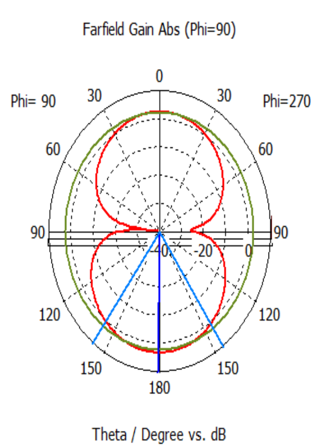
(b)

Figure 6: (a) S11 (b) VSWR of slot length

Figure 7 shows the two-dimensional radiation pattern of Koch fractal shaped antenna at 4.0037, 4.2, 4.47, 4.7, and 5.0 GHz frequencies respectively. The radiation pattern is the almost omnidirectional pattern, and the simulated beam width of the fractal antenna is 73.9, 72.3, 70.1, 68.5 and 66.0 degrees respectively.



(a)



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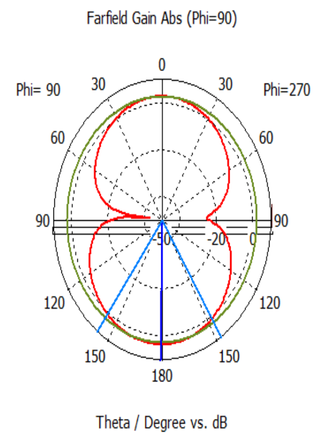

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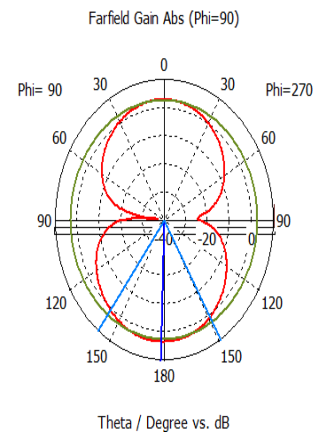

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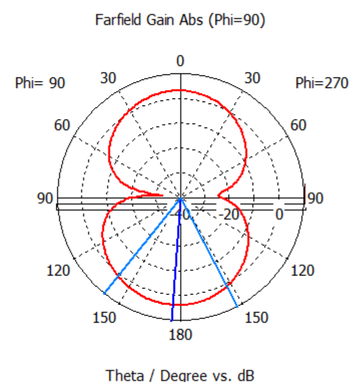
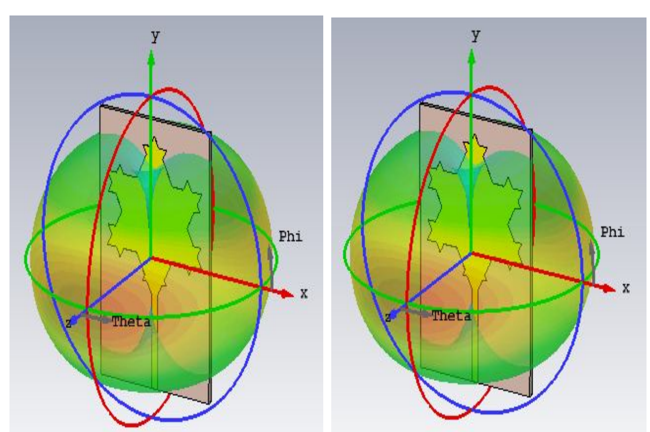


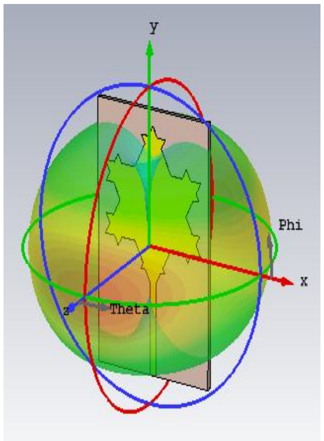
(e)

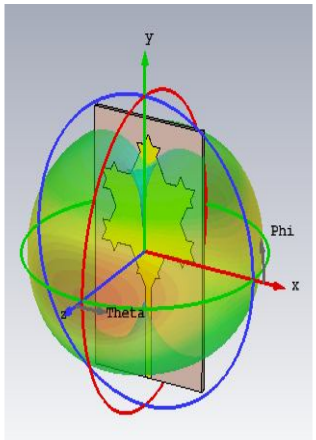
Figure 7: 2D Radiation Patterns at different operating bands in (a) 4.0037 GHz (b) 4.2 GHz (c) 4.47 GHz (d) 4.7 GHz and (e) 5 GHz

The equivalent 3D radiation patterns are shown in Figure 8. The gain that observed at 4.0037 GHz is 2.878 dB, 4.2 GHz is 3.001 dB, 4.47 GHz is 3.164 dB, 4.7 GHz is 3.321 dB and 5.0 GHz is 3.545 dB respectively. The simulation patterns give the constant radiation patterns in the wide frequency range and give the almost constant gain in the entire operating frequency range.

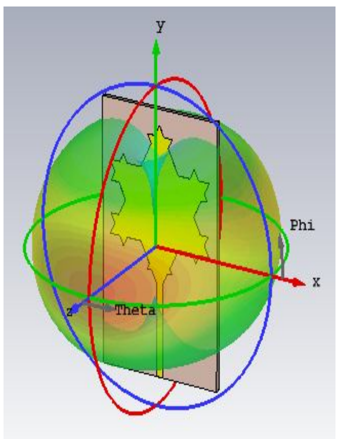


(a) (b)





(c) (d)



(e)

Figure 8: 3D Radiation Patterns at different operating bands in (a) 4.0037 GHz (b) 4.2 GHz (c) 4.47 GHz (d) 4.7 GHz and (e) 5 GHz

3. CONCLUSION

A Koch FA for wideband applications is proposed in this paper. The Koch Fractal consists of two triangular slots (one inverting on another) with DGS ground plane. The presented Koch antenna size is 29 x 47 x 1 mm^3. The final antenna shows wider bandwidth and constant gain. The antenna has been optimized to operate from 2.89 GHz to 7.09 GHz. The modeled results show that the proposed FA could be a good challenger in Wide Band applications like Wi-Max and WLAN.

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