Design And Analysis of A Compact Fractal Patch Antenna with Improved Radiation Properties for UWB Applications

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Abstract- *In this paper the design of a compact Fractal Patch Antenna (FPA) is presented. This MLA antenna has been designed on FR4 substrate εr = 4.4 and thickness h = 1.53 mm. A partial ground plane is used for impedance matching and koch fractal patch are simulated to miniaturization of antenna. There is a reduction of patch area around 30% with the proposed antenna compared to the square patch of the same size. The overall dimensions of the designed Proposed FPA antenna are 20.0x20.0x1.6mm3. The result after the simulation of FPA antenna has excellent ultrawide band bandwidth from 2.5 GHz to 11.6 GHz corresponds to 134.82% impedance bandwidth (9.1GHz) at VSWR 2:1. This ultrawide band (UWB) characteristics of antenna has been achieved by using the partial gnd concept. This forthcoming antenna shows 8.2 dB improvement in the isolation. The result obtained after simulation gives radiation pattern of FPA antenna which is nearly omnidirectional in azimuth plane and bidirectional in elevation plane.*

Keywords- UWB, Slotted, Fractal, Meandering Line Patch and Miniaturization.

I. INTRODUCTION

UWB is one of the most interested wireless communication systems which can be used for monitoring, positioning, security, microwave imaging and various communication application. Due to its high gain, omnidirectional radiation pattern, high data resolution, low complexity, inexpensive properties, it is becoming more attractive research phenomena for students and wireless communication. The antennas with ultra wideband frequency have been broadly researched and developed after the declaration of the unlicensed bandwidth of 3.1 to 10.6 GHz as UWB by Federal Communication Commission (FCC) [1].Printed slot type antennas are mostly accepted for UWB application. It is still a challenge to antenna designers to design a compact, cost effective, high gain ultra wideband antennas.

In recent years, due to its various number of benefits including stable radiation pattern, high gain, low profile and inexpensive fabrication the printed microstrip slot antennas were significantly researched. For UWB applications numerous antennas were designed. Among them, one of the antenna requires a large ground plane that rises dimension. As a result, that is not included in microwave integration [2]. Various line feeding and waveguide feeding antennas were offered for UWB applications. For achieving the characteristics of wide impedance bandwidth monopole architectures are commonly used, such as elliptical, pentagon, rectangular, square, hexagonal, annular ring and circular ring antennas [3-7].

A small elliptical ring antenna with a coplanar waveguide for UWB application was inspected by Ren et al. Wideband frequency has been attained by this antenna ranging 4.6 – 10.3 GHz which doesn’t cover whole UWB. Again the full UWB was not attained by this antenna despite compacted size [8]. A printed rectangular with dual circular slot patch monopole antenna is proposed which acquires operating bandwidth with a range of 3 – 11.5 GHz which covers the entire UWB region. Although the size of the proposed antenna has been reduced and antenna performance has been enhanced significantly. The antenna is compact in size than antenna stated in ref [9] and In expensive for fabrication for using low-cost FR4 substrate. The spectacles slot shape patch with microstrip line-fed and tapered slot ground make it perfect for UWB applications.

In this paper, a Fractal microstrip patch with partial slot ground plane organized high performance stable radiation pattern, a compact antenna with a compact dimension of 20 × 20 mm2x1.6mm2 is presented. Due to Koch slot patch with microstrip line-fed and partial ground plane the proposed antenna reached the wide bandwidth ranging 2.5-11.6 GHz which makes it significant for using ultra wideband application. Proposed antenna showing 8 dB improvement in the isolation between the co-pol to cross-pol radiations.

II. GEOMETRY AND WORKING PRINCIPLE

The dielectric chosen is FR4-epoxy substrate having relative permittivity of 4.4 and the thickness of 1.6mm. The resonant frequency of the rectangular patch antenna, of length L and width W can be calculated using the following formula.

Step 1: Calculation of Lambda (λ)-

Lambda (λ)=c/f=3x10^8/6.8^9

(λ)=44mm at 6.8 GHz

Because (3.1+10.6/2=centre freq=6.8GHz)

Step 2: Calculation of L & W -

The center frequency will be approximately given by:

$$f_c \approx \frac{c}{2L\sqrt{\varepsilon_r}}$$

$$L = \frac{C}{2fc\sqrt{\varepsilon_r}} \quad \text{------------ (1)}$$

Where fc=is centre freq=6.8GHz

εr=4.4 and c=3x10^8

L=9.84mm

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad \text{------------- (2)}$$

For c=3*10^8 m/s2, *fr*=6.8GHz, ε *r*=4.4

We get **W=12.42mm.**

Step 3-Feed width calculate by using

$$Z_0 = \frac{60}{\sqrt{\varepsilon_r}} \ln\left(8\left(\frac{H}{W_f}\right) + 0.25\left(\frac{W_f}{H}\right)\right) \quad \text{--------- (3)}$$

We get Wf=2.8mm

Step 4: Calculation of Feed length (Fl)-

Feed length (Fl)=λ /4*sqrt (4.4)

Fl=5.5mm

Step 5: Calculation of Substrate dimension-

Ls=L+6h=10+6*1.6=19mm

Ws=W+6h=13+6*1.6=23mm

Step 6: Slot dimensions:

L1 = L/4=2.35mm

We take optimum values of L1 is 2.5mm

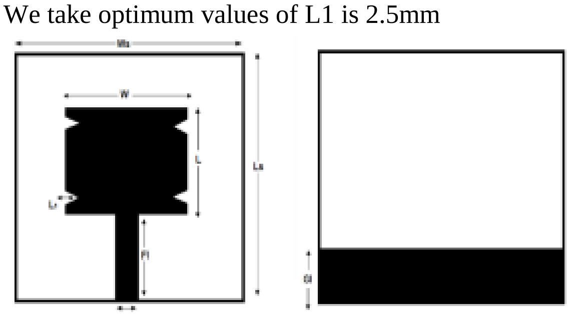
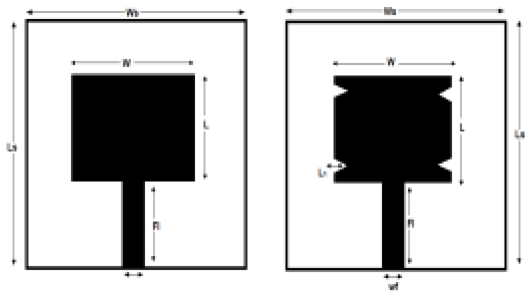


Fig.1 Geometry of the Proposed UWB fractal patch antenna

The proposed antenna is optimized by using the HFSS simulation software and the optimized parameters are:

L = 9.4mm, W = 12.8mm, L1 = 2.5mm, Wf = 2.0mm,Fl=6.0mm Ls = 20mm, Gl=5.5mm Gw=20mm and Ws = 20mm

Figure 1 shows the design of both proposed UWB fractal patch antennas and its dimension. As shown in the Figure, the patches are fed by microstrip line.



(a) Traditional Patch Antenna (b) Modified Patch Antenna

Fig.2 Generation of Proposed UWB Fractal antenna

III. RESULTS AND DISCUSSIONS

Simulation of this proposed Koch fractal antenna has been carried out in HFSS. The simulation results are given in the following section:

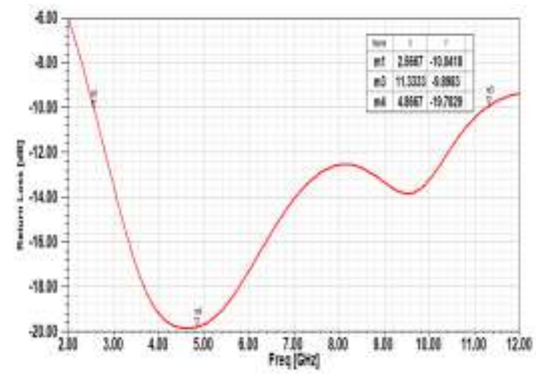


Fig.3 .Return Loss of Proposed Antenna

The simulated result of proposed antenna is operated on UWB band that is 2.5 to 11.6GHz respectively.

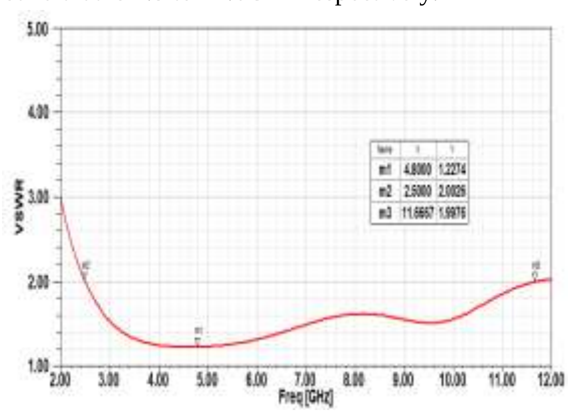


Fig.4VSWR of proposed antenna

The simulated result of FPA antenna exhibits the excellent ultra-bandwidth (UWB) from 2.5 GHz to 11.6 GHz corresponds to 133.83% impedance bandwidth (9.1GHz) at VSWR 2:1.

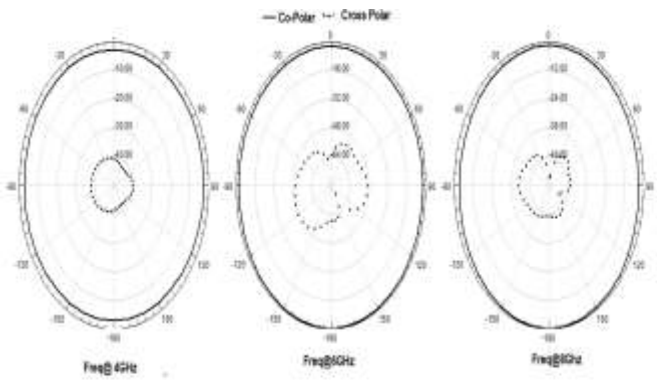


Figure 5. Radiation patterns for the proposed antenna with copolar and cross-polar in H plane at resonant frequencies (a) 4 GHz, (b) 6 GHz and (c) 8 GHz

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Fig.5 it is observed that the radiation patterns of antenna are Omnidirectional in H plane at freq 2.4GHZ. and cross polarization in improved by using Koch fractal patch antenna

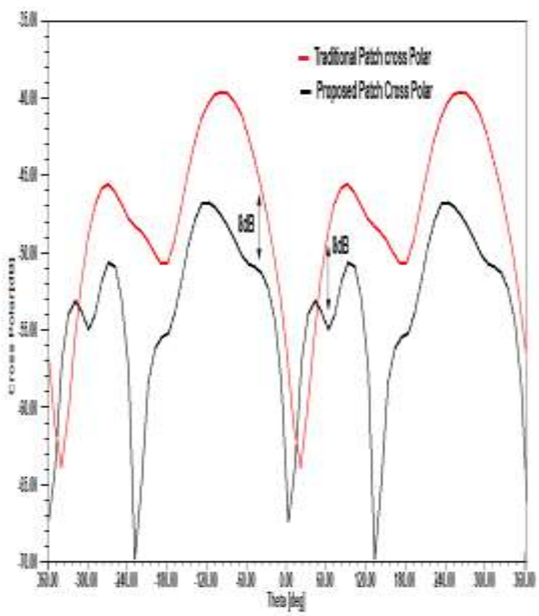

Figure 6. copolar and cross-polar in H plane at freq 6.8Ghz

The radiation patterns in H-plane at 6.8 GHz are shown in Fig. 6. The simulated results of proposed patch confirm a reduction in XP level by about 8 dB as compare to traditional patch antenna.

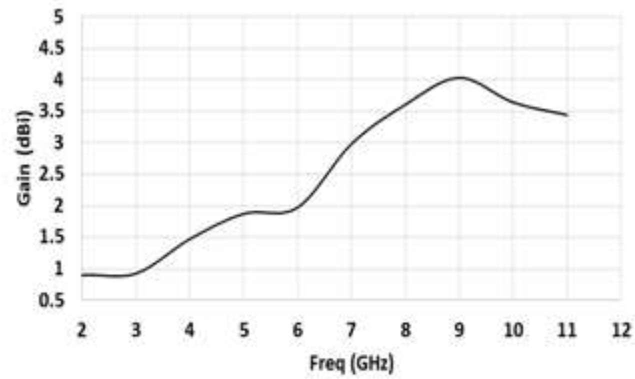

Figure 7. Freq Vs Gain of proposed antenna

The proposed antenna gain is shown in Fig. 7 which is indicated the maximum gain of 4 dBi at 9 GHz. Gain variations is from 0.8 dBi to 4 dBi over the UWB band of 2.5 to 11.0 GHz.

IV. CONCLUSION

In this paper, a UWB Fractal patch antenna has been proposed. The proposed monopole fractal antenna offers UWB characteristics from 2.5 GHz to 11.6 GHz at VSWR 2:1. It is observed that the radiation patterns of antenna are omnidirectional in H-plane and bidirectional in E-plane over the entire operating bandwidth. The simulated gain of patch is around 4.0dbi. The H-plane XP value without koch is about 42 dB below the CoP and that get reduced by 8 dB resulting in over 51 dB isolation between CoP-to-XP radiations. The proposed fractal antenna is compact, low profile, and offers very large impedance bandwidth required for next generation UWB system.

Many Comparison has been study for UWB applications. The use of Koch fractal in patch makes the design conformal and more suitable for the miniaturized applications. Such type of antenna can be useful for UWB system as well as suitable for various military and commercial wideband applications.

REFERENCES

[1] Zhenya Li, Xiaosong Zhu and Jianhua Zhang, “Compact Dual Polarized MIMO Antenna for UWB Communication Applications”, IEEE Trans. Antennas Propag. Aug. 2018

[2] Foez Ahmed, Nisab Hasan and Aurangzib Md Abdur Rahman, “A Compact Planar Multiple-Input Multiple-Output (MIMO) Antenna for Ultra-wideband Applications”, 3rd International Conference on Electrical Information and Communication Technology (EICT), 7-9 December 2017.

[3] R. Chithradevi, B. S. Sreeja, “A Compact UWB MIMO Antenna with High Isolation and Low Correlation for Wireless Applications", IEEE Trans. Antennas Propag. Aug. 2017.

[4] Nagaraj Hanchinamani, Dr. C.R. Byrareddy, “A Spanner Shaped Ultra Wideband Antenna For Mimo Application”, International Conference on Innovations in information Embedded and Communication Systems (ICIIECS), 2017.

[5] Avnish Kumar Giri, Sasmita Pahadsingh and Sudhakar Sahu, “Compact MIMO Antenna System with High Isolation for Ultra-Wideband Applications", IEEE WiSPNET 2017.

[6] Minal Dhanvijay, Anuradha Pattekar and Rajiv Kumar Gupta, “Compact Circular Ring Shaped Monopole UWB MIMO Antenna, 2017 IEEE 3rd International Conference on Sensing, Signal Processing and Security (ICSSS), Aug. 2017.

[7] Tayyab Shabbir, Rashid Saleem and Muhammad Bilal, “UWB-MIMO Doublet with Split Decoupling Structure and Defected Grounds," IEEE MTT-S International Conference on Numerical Electromagnetic and Multiphysics Modeling and Optimization for RF,Microwave, and Terahertz Applications (NEMO), 2017.

[8] Abdullah Alfakhri, Muhammad Ahmad Ashraf, “Design and Analysis of Compact Size Dual Polarised Ultra Wideband MIMO Antennas with Simple Decoupling Structure”, IEEE Trans. Antennas Propag. Aug. 2016.

[9] Avez Syed and Rabah W. Aldhaheri, “A Compact Ultra-wideband MIMO Antenna with Improved Isolation," IEEE Antenna Wireless propag. Lett., July 2015.

[10] J. Ren, W. Hu, Y. Yin, and R. Fan, “Compact printed MIMO antenna for UWB applications," IEEE Antenna Wireless propag. Lett., vol. 13, pp. 1517_1520, 2014.

[11] L. Liu, S.W. Cheung, and T. I. Yuk, “Compact MIMO antenna for portable devices in UWB applications," IEEE Trans. Antennas Propag., vol. 61,no. 8, pp. 4257_4264, Aug. 2013.

[12] T. S. P. See and Z. N. Chen, “An ultrawideband diversity antenna," IEEE Trans. Antennas Propag., vol. 57, no. 9, pp. 1597_1605, Jun. 2009.