Design And Analysis of Compact Multiband Double Inverted TFractal antenna with Enhanced Bandwidth for WLAN Wi-Fi and WiMAX Applications

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Abstract

This paper proposes a new design approach for Multiband coplanar waveguide (CPW)-fed double inverted T Shape fractal patch antenna which generates two wide resonant frequency bands for -10-dB S11 bandwidth to cover WLAN(2.4GHz),WiMAX(3.30GHz) and Wi-Fi(5.50GHz) simultaneously. To achieve multiband operation, a second-iterative fractal-radiating patch is printed on a single substrate layer and a CPW structure is used to feed this antenna. For numerical analysis, optimization, and electromagnetic (EM) modelling of the prototype structure, HFSS is used. To assess the antenna performance in terms of impedance bandwidth, radiation pattern, realized peak gain, and efficiency, ANSYS HFSS is employed. The simulation results show that PRFPA has a compact size (50× 58 × 1.6 mm3), planar, simple design and low-cost to be manufactured. In addition, the proposed antenna operates in Multiband, it has good stable omnidirectional radiation patterns, and the gain over the operating bands are 4.1 dB, 4.5 db and 4.8 dB, respectively.The simulated results shows that the proposed antenna achieves good impedance matching an operating bandwidth of 360MHz, 500MHz and 1100MHz at 2.40GHz, 3.3GHz and 5.50GHz respectively. Thus it covers WLAN 2.4–2.60 GHz, Wi-MAX 3.10-3.60GHz and Wi-Fi 5.0-6.0GHz band.

INTRODUCTION

In the modern communication systems and semiconductor technological developments, an extensive variety of wireless services has been successfully used worldwide from the past few years. In the modern communication systems antenna plays a very important role. Complexity is reduced and the performance of the receiver is enhanced by the well-designed antenna. Based on the application and the operating frequency of the antenna, the dimension, type and the configuration of the antenna will be chosen. In wireless communication systems, a broadband system has been playing a very important role for wireless service requirements. Worldwide Interoperability for Microwave Access (WiMAX)/ Wirelesslocal area network (WLAN) provides portable mobile broadband connectivity and thus provides a wireless alternative to cable and Digital subscriber line for (DSL) Broadband access and it is adopted for mobile devices, laptops and smart phones [2].

In modern wireless communication systems, multiband antenna has been playing a very important role for wireless service requirements [3]. Now-a-days WLAN and WiMAXhave been widely applied in mobile devices such as hand held computers and intelligent phones. These two techniques have been widely recognized as a viable, cost-effective, and high speed data connectivity solution, enabling user mobility with the rapid development of the modern wireless communication system, antenna design has turned to focus on wide multiband and small simple structures that can be easy to fabricate. To adapt to the complicated and diverse WLAN and WiMAXenvironments suitable for WiMAX applications have rapidlyincreased. There are three bands of operation for WiMAXtechnology which are 2.4 GHz (2.5 - 2.8 GHz) called the lowband,3.2 GHz (3.2 -3.8 GHz) called the medium-band and 5.3GHz (5.2 - 5.8 GHz) called the high-band respectively, Since,WiMAX offers multiband operation, microstrippatchantennas are highly preferable. The microstrip patchantennasare popular due to their low-cost, small size, light-weight andEasy fabrication [4].

In this paper, a MultibandT shaped fractalmicrostrip patch antennais designed, optimized and simulated. The antenna covers twofrequency bands of 2.2 -2.6 GHz, 3.1-3.6Ghz and 5.0-6.1GHz. Theproposed antenna can find applications in severalcommunication standards used in WLAN/WiMAX/Wi-Fi.

ANTENNA CONFIGURATION

The proposed T shape Multiband fractal antenna prototype is illustrated in figure 2. In this design, a CPW Fed fractal antenna is presented. The design of the antenna starts with a single element using basic rectangular patch which has the dimension of 27.83mm*36.08mm, operating at frequency 2.45GHz with the help of standard formulae given for rectangular patch antenna. The overall size of the substrate is 56mm*66mm.Simulation has been done using an electromagnetic set up solver FEM. The antenna has design up to the 2nd iteration. It has designed on Epoxy FR-4 substrate with thickness of the substrate is 1.6 mm, dielectric constant of 4.4. The conducting material has chosen as copper clad. For designing an antenna an essential parameters are required can be calculate according to the transmission line method which are width (W), length (L), resonant frequency (fo) and the height of substrate (h). The predictable microstrip

Double inverted T shape fractal antenna has designed by adopting the standard measures.

1. Width (W) of antenna, calculate by,

$$W = \frac{c}{2 f_0 \sqrt{\frac{\varepsilon_r + 1}{2}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

f0 = 2.45 GHz, ε r = 4.4, c = 3 × 10m/s
We get, W = 38.08 mm
2. Effective dielectric constant (εreff), which is determined by,

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-0.5} \quad \ldots\ldots\ldots(2)$$

For εr=4.4, h=1.6mm, W=29.25mm
We get εreff=3.99
Step 2: Calculation of Length of Patch (L)-
The effective length due to fringing is given as:

$$L_{eff} = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}} \quad \ldots\ldots\ldots\ldots(3)$$

For c=3*10^11 mm/s, εreff=3.99, f o=2.4GHz
We get Leff =29.25 mm
Due to fringing the dimension of the patch as increased by ΔL on both the sides, given by:

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{w}{h} + 0.8\right)} \quad \ldots\ldots\ldots(4)$$

For W=29.25mm, h, =1.53mm, εreff=3.99
We get ΔL=0.70mm
Hence the length the of the patch is:
L= Leff-2ΔL=28.4 mm
Dimension of ground plane (Ls) and (Ws) are determine by
Ls=L+2*6h=28+2*6*1.6=48mm
Ws=W+2*6h=38+2*6*1.6=56mm

From fig. 1, the width (Gl) of the ground plane on each Side of the CPW middle. Spacing (g) between ground plane and central patch and the separation (Sp) between ground plane and patch feed line is 3.6 mm.CPW feed has used for exhibiting wide bandwidth toning, coplanar ability lower dispersion at upper frequencies and easiness of design and fabrication. L = 27mm, W = 37mm, L1 = 13mm, L2=8mm W1=8mm, W2 = 4.8mm, Fl = 15mm, Gl = 23mm, g=0.7mm, Ls = 50mm, Gl=8mm and Ws = 58mm and Sp=3.6mm Figure 1 shows the design of both proposed Koch fractal patch antennas and its dimension. As shown in the Figure, the patches are fed by CPW

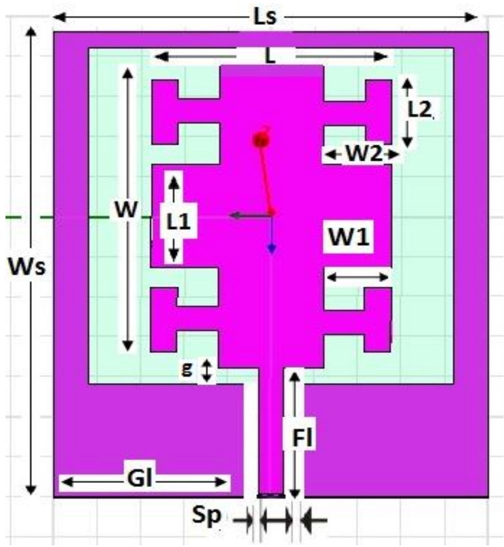

Fig.1Proposed Double inverted T Shape Fractal Patch Antenna

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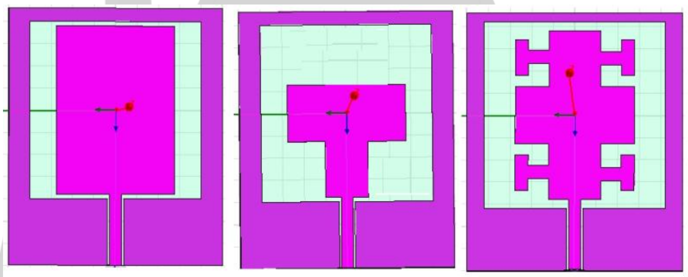

(a) 0th iteration (b) 1st iterations (c) 2nd iterations

Fig. 2. Configuration of the proposed double inverted T shape antenna with CPW Feeding

In our present work we have mainly focused on generating of Multiband characteristics which yields increases the bandwidth and reduced the size of antenna. From fig.1, rectangular patch has used as base shape and in 0th iteration, T shape patch have scaled of the order of 1/3 of base formused as generator. In first iteration one T shape patches have again scaled of the order of 1/3 of base form have been located touching the base shape. Likewise second iteration has taken by further placing four T shape shaped patches at again reduced scale of the order 1/3. It has been established that as the iteration number and iteration factor increases, the resonance frequencies become lower than that of the previousone that represents the double inverted T shape patch.

RESULT AND DISCUSSION

The proposed double inverted T shape fractal antenna has simulated and analyzed using HFSS software and verified up to 2nd iteration between the frequency ranges 2 to 10 GHz. The 2nd iteration is found to have better antenna parameters compared to the 0th and 1st iteration. From fig.3, the return loss plot has been found that antenna coordinated in three resonant frequencies effectively below -10 dB which is appeared at 2.41GHz, 3.30 GHz and 5.5 GHz respectively. The return loss in Multiband are suitable and all bandwidth are wider as shown in fig.3. From the return loss plot it has observed that antenna has suitable for IEEE WLAN/Bluetooth (2.40-2.50 GHz), WIMAX (3.20-3.60 GHz) and Wi-Fi (5.0-6.0GHz). The finest results are obtained for 2nd iteration. Iteration plays significant role in achieving dual frequency and wider the bandwidth. Return loss result after 2nd iteration has shown in fig.3

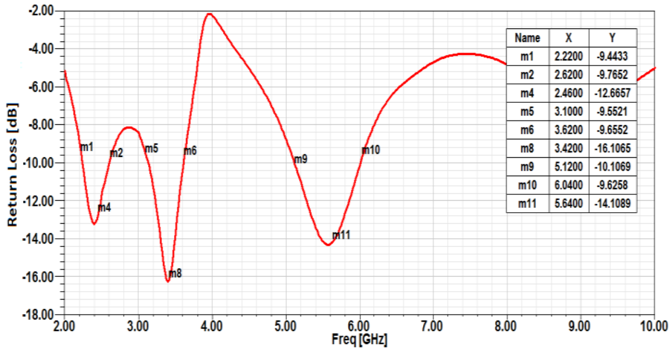

Fig 3: Return loss of the proposed Double inverted T Shape fractal antenna

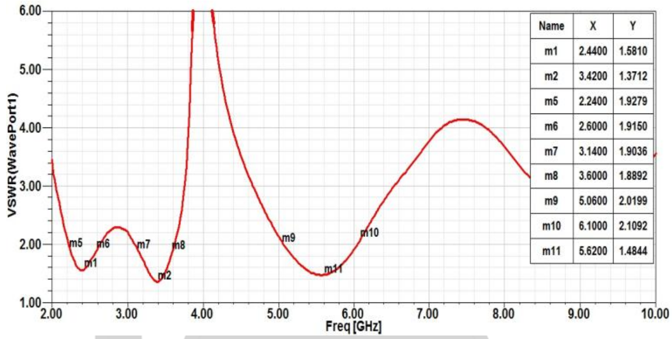

Fig.4VSWR of proposed antenna

The value of VSWR is not as much of 2 for the antenna to work efficiently. Fig.4 shows, VSWR vs. frequency plot, it isfound that the VSWR is in between 1 and 2 at each frequency band 2.4 GHz, 3.3GHZ and 5.5GHz.

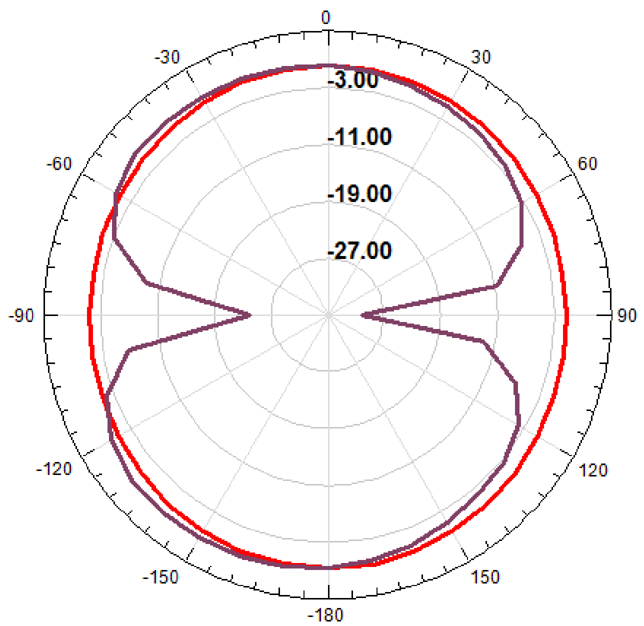

Fig.5Radiation pattern

Fig.5 it is observed that the radiation patterns of antenna are Omnidirectional in H-plane& bidirectional in E plane at freq 2.4GHZ.

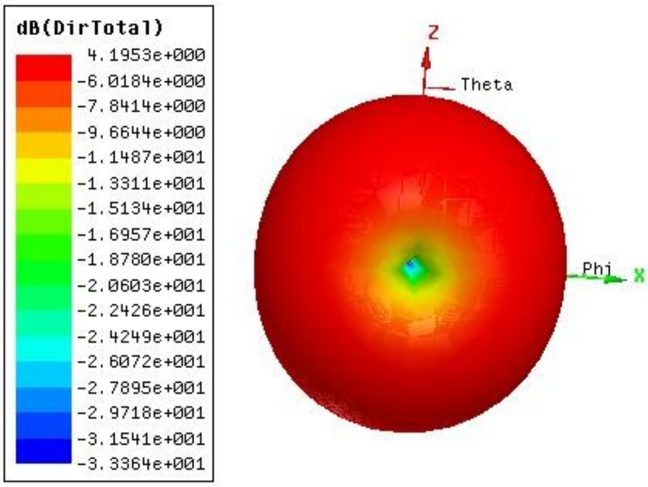

Fig 6: 3D Gain

The simulated gain of the antenna at 2.45 GHz is presented in Figure 8.The maximum gain is 4.1dBi at 2.45 GHz.

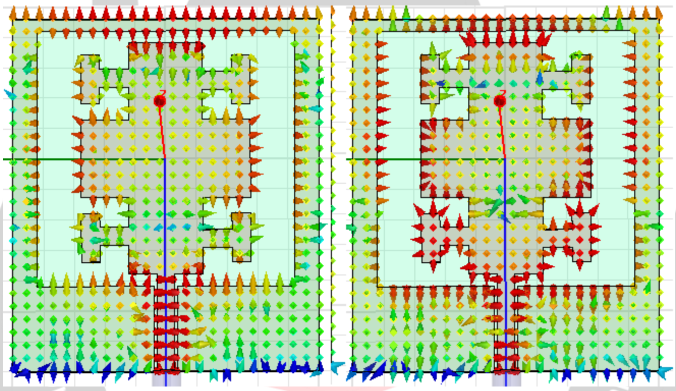

Fig.7Surface current distributions

The current distribution of the antenna at 2.4 GHz & 3.3GHz is presented in Figure 7. it has been seen that the magnetic current at the middle gap and the electric current on the patch section of theantenna around the gap is crucial for resonance and radiation characteristics of such antenna Red arrow indicates maximum current along the edge of radiating patch.

COMPARISON TABLE

To improve the performance of this antenna, double inverted T shape asymmetric shape is introduced .As seen from the table, number iterations increases then higher freq is shifted to lower side. It conclude that proposed patch antenna technique's both bandwidth & compact size of antenna has been improved.

TABLE I COMPARISON OF ITERATIONS

Sr.No.	Iteration wise Results	Freq (GHz)	Return loss (dB)	VSWR	BW (MHz)	Gain (dB)
1.	0^{th} iteration	5.0	-18.16	1.28	170	4.7
2.	1^{st} iteration	2.41	-19.94	1.29	280	4.4
		9.21	-23.40	1.22	801	4.8
3.	2^{nd} iteration	2.43	-13.12	1.58	360	4.1
		3.39	-16.29	1.37	500	4.5
		5.50	-14.10	1.54	1100	4.8

CONCLUSION

A double inverted T shape fractal structure geometry has just been investigated and found to be an easy and effective method to shrink the antenna size as well as excite additional resonance modes. FractalGeometrical Structure adds an extra degree of freedom inmicrowave circuit design and opens the door to a wide rangeof application.

A compact double inverted T shape CPW feed Multiband fractal antenna has investigated in this paper. The simulated results shows thatthe antenna has a good return loss, and the antenna gain isnear 4 dB at the considered frequency and other Multiband frequencies suitable for IEEE WLAN/Wi-MAX/Wi-Fi at 2.40-2.50GHz,WIMAX at 3.40-3.60 GHz and Wi-Fi at 50-6.0GHz. The geometry has implemented by using HFSS electromagnetic tool as simulation software. Furtherimprovement is possible if more number of iteration isintroduced or by further modifying the ground plane used.Since it reveals excellent Multiband characteristics, it hasfound its application in wireless. The proposedmicrostrip antenna assures compactness, wide bandwidth in design and ease in fabrication.

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