CPW FED DUAL BAND NOTCHED FRACTAL PATCH ANTENNA FOR UWB APPLICATIONS

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Abstract: - Modern communication systems put demands on antennas which operate over multiple range of frequencies, with in shrunken size, less weight and high gain. For wireless applications like wireless home networking, wireless USB, Ultra Wide Band (UWB) antenna plays an important role. For achieving UWB performance, a coplanar waveguide (CPW) fed fractal tree patch antenna is proposed. As UWB operates under a wide range of frequency band, for achieving band rejection function, a Folded T-Shaped Element (FTSE) is embedded in the radiating patch. The notch band is 3.3-4.2GHz. The simulated results showed that the antenna exhibits preferred VSWR levels in the entire impedance bandwidth. Pair of rectangular notches are included in the ground plane for extending the antenna's impedance bandwidth. The results show that the antenna covers the frequency range from 3.1-11.1 GHz with VSWR $\leq$ 2. Dimensions of antenna are $14 \times 18 \times 1$.

Key Terms: Band-stop, Co Planar Waveguide (CPW), Ultra Wide Band (UWB), fractal patch, Folded T-Shaped Element (FTSE).

I Introduction

Communication systems operating in Ultra-Wide Band (UWB) range comprises of wide band width range, allowing high speed data rate transmissions [1]. The Federal Communications Commission (FCC), assigned the usable band width for antennas working under UWB range as 3.1-10.6GHz [2]. This UWB technology offers many advantages over regular narrow band technology, as less power utilization, transmission of data at high data rates, more resistant to multi path prorogation, less hardware complexity. This technology is named as cable replacement technology. For the systems which include high speed communications, wireless speakers, high speed Wireless Personal Area Networks (WPAN), sensor networks, wireless USB, antenna employing in UWB range is the key factor.UWB antennas can be designed using planar technology, which can be integrated with microwave Integrated Circuits (MICs) easily, with in less cost [3]. For implementing this UWB technology, antennas exhibiting multiband performance with in shrunken size are required. If conventional antennas are used for implementing this technology, lowering the profile of these antennas results in some disadvantages like reduction of antenna dimensions less than a quarter wavelength of operating wavelength, less gain and directivity. So for UWB technology antennas which are electrically small should be used. So here

fractal geometries can be utilized, which have space filling and self similarity property, which can be helpful in scaling up the antenna performance [4]. One of the major advantages of using fractal based structures is that, effective coupling of energy in to the medium. [5]-[7]. Also various feeding methods can be used for fractal antennas without affecting their performance, such as micro strip lines [8], Coplanar Waveguide (CPW) [9], CPW transmission-line feeding.

The major issue for the systems working in UWB range is interference. To overcome this drawback one of the solutions is using filters, like Frequency Selective Surface (FSS) [13]. But these occupy added space, which violates the advantage of miniaturization. So to overcome this problem, band rejecting function needs to be included within the antenna used for UWB communication. This can be implemented by 1)Arranging definite shaped slots (C-Shaped, L-Shaped) on the radiating element [14]; 2)Using parasitic elements beside the radiating element, for eliminating specific band [15]; and 3)Inserting slits in the ground plane or feedline [16].

Here, a UWB antenna with band rejecting function, fed by a coplanar waveguide is proposed. The antenna used is a fractal tree shaped structure. For achieving band rejection function, a folded T-shaped structure is embedded in the radiating element. Antennas impedance bandwidth ca be extended by curving the ground plane near the patch, and by cutting out the rectangular notches from it's sides. Antennas impedance band width can also be improved by adding more number of fractal

Fig. 1. Design of proposed fractal antenna.
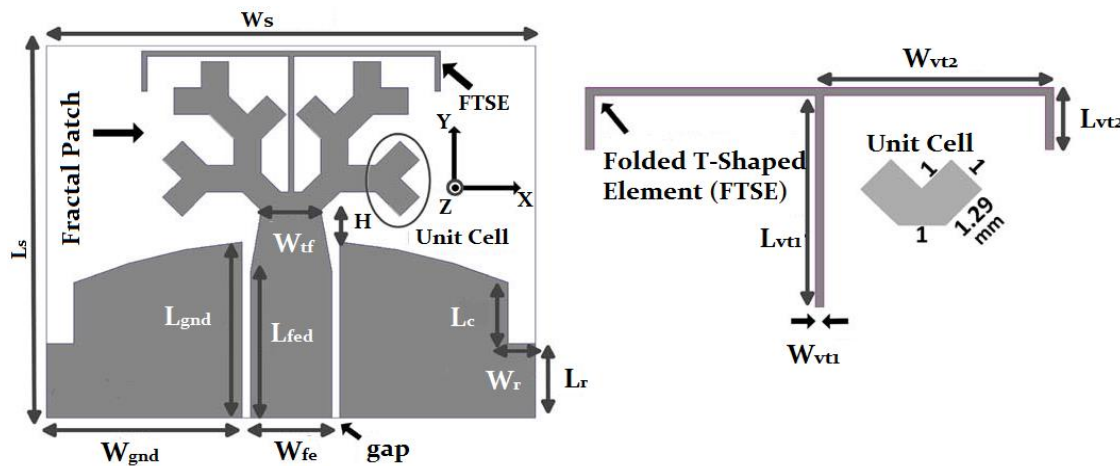
Cells. Frequency of the band which needs to be rejected can be tuned by adjusting the length of the arms of T-shaped element. Here lengths of T-structured arms are choosen such that, WIMAX (IEEE802.16, 3.3-3.7 GHz) and downlink frequency of C-band satellite communication (3.7-4.2 GHz) are eliminated from in use band. In this paper, section 2 describes about the construction of the proposed antenna, and the parameters used for optimization. Section 3 describes about measured and simulated results of the proposed antenna. Finally section 4 concludes the paper.

II Design of antenna

The design and factors of the patch antenna are as shown in Fig. 1. Here the substrate which we are using for printing the antenna is FR4, having a thickness of 1 mm, tan δ of 0.024, and relative permittivity of 4.4. The size of the substrate is $W_{sb} \times L_{sb}$ and the width of the feed line is taken as W_{fe} = 3mm, such that characteristic impedance of the antenna will be 50Ω. For making the impedance toning between feedline and fractal patch, the feedline is tapered [7].

UWB antenna used here comprises of CPW feedline, Fractal tree patch, containing group of fractal unit cells, which forms the branches of the tree, and a T-shaped component. In order to improve matching properties between patch and the feedline, ground plane is curved at the top and rectangular slots are removed from its sides as shown in Fig. 2. For obtaining band denial function, T-Shaped element is entrenched in the radiating element. The length of T-Shaped element decides the rejecting function of the radiator. The process for designing the antenna includes the following steps

1) Make a CPW feedline, which is narrowed at one end.
2) Append four unit cells for forming the branch.
3) Append an additional four unit cells
4) Do modifications to the ground plane for extending the impedance bandwidth of the radiating
5)

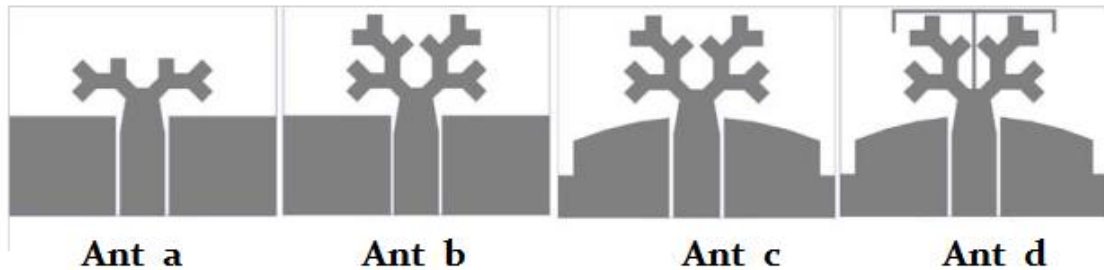

Fig. 2. Step by Step development of fractal patch.

Element, to exhibit UWB range.
6) Insert a T-Shaped component in to the radiating element.

Using MATLAB, the parameters of antenna are optimized. The parameters are as stated: W_{sb}=18mm, L_{sb}=14mm, W_{fe}=3mm, L_{fed}=5.5mm, gap=0.3mm, W_{tf}=2.2mm, h=1.79mm, W_{gnd}=7.2mm, L_{gnd}=6mm, L_r=2.2mm, W_r=1mm, L_c=2.3mm, L_{vt1}=5.1mm, L_{vt2}=1.5mm, W_{vt1}=0.2mm, W_{vt2}=5.5mm. The extent of L_{notch} is made as $0.5\lambda_g$, where λ_g corresponds to rejectable frequency of 3.7GHz.

III Results and discussion

Here the parameters of the proposed antenna are discussed, and equivalent outcomes are offered. The consequence of each factor was observed by varying the parameter in question at the same time time without varying other factors. It was observed that the length of the ground plane (L_{gnd}) has a foremost effect on the impedance matching of the antenna. Fig3 explains about the changes in VSWR with changes in L_{gnd} for Ant-a and Ant-b. The higher and lower cut off frequencies of the UWB response of the antenna can be proscribed by shaping the top of the ground plane as a curve, and inserting rectangular notches in its sides, converting Ant. a to Ant. b. The VSWR of Ant. b is a little bit affected by changing the dimensions of rectangular slot pattern in the ground plane, as shown in Fig 4. This figure noticeably depicts how the rectangular notches in the ground plane can pull out the antenna's impedance band width, i.e., the lower band boundary extends from 9.89 to 11.1 GHz, thus obeying the necessity of UWB band. It is observed in Fig. 4 that by increasing both parameters from their optimized value (W_r=1mm and L_c=2.3mm), the toning properties deteriorates along with some cut back in the band width performance.
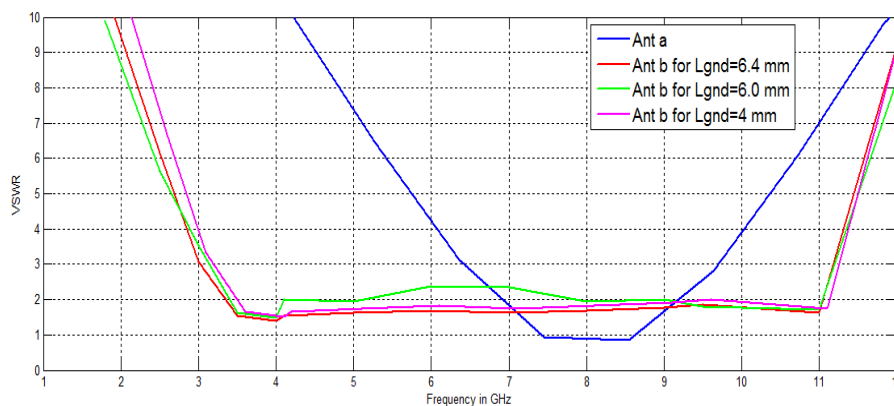

Fig. 3 Simulated characteristics of VSWR, for Ant. a and Ant. b, in terms of L_{gnd}.
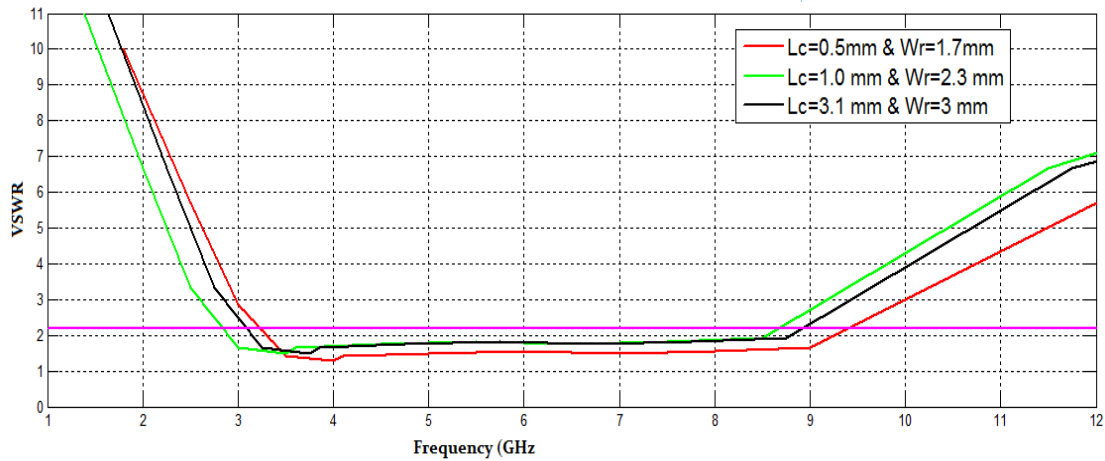
Fig. 4. Simulated VSWR in terms of ground plane dimensions for Ant. c.

The proposed fractal patch is comprised of iterating unit-cell structures in which the Folded T-shape element configuration is implanted to for making the antenna to perform rejecting function. It is apparent that by increasing the repetition of fractal patch, the antenna's impedance toning can be enhanced. The method of accumulating band rejection function to the antenna contains of three steps.

Step 1) A single vertical stripline is added to fractal patch of antenna.

Step 2) A couple of horizontal arms is added to vertical stripline.

Step 3) A pair of vertical arms are added to above step

As shown in Fig. 5, the vertical strip line element routes to diminution in antennas bandwidth to mismatch. However, by adding two horizontal arms, to the vertical strip line, impedance bandwidth increases and rejecting property can be observed.

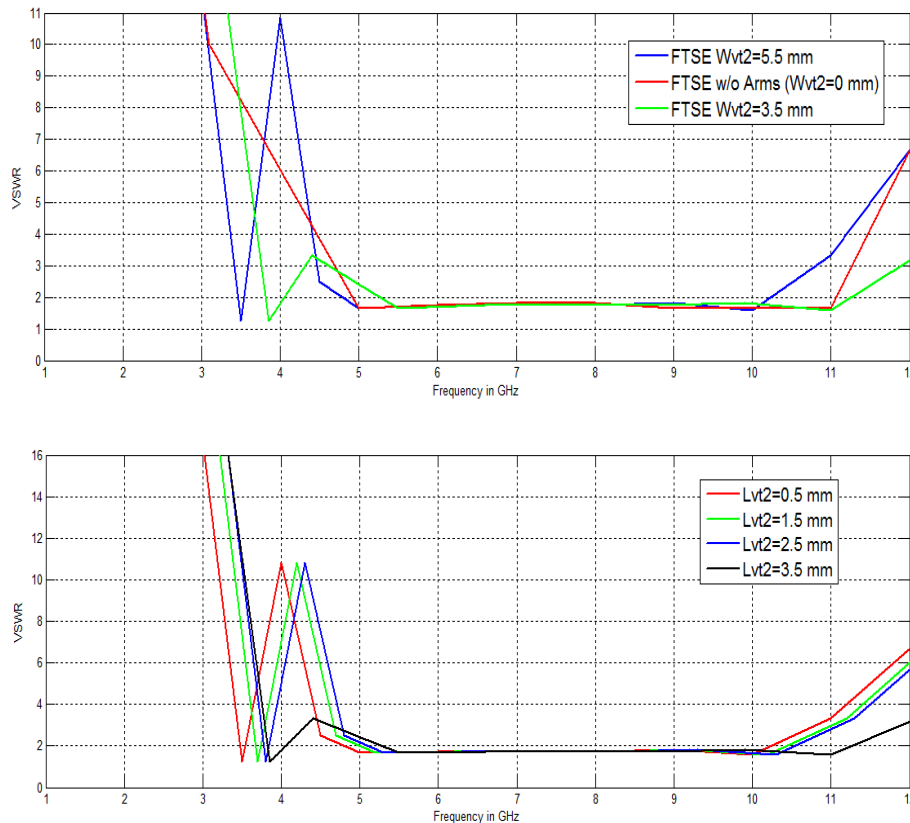5. Simulated VSWR curves with dissimilar values of W_{vt2} for Ant. d

Fig. 6. Simulated VSWR curves for Ant. d in terms of arm lengths of FTSE, with unchanging arm width (W_{vt2}) of 5.5mm.

The effect of width of folded T-Shaped element on Ant. d is shown in Fig. 5. The dimension of the width determines the quantity of rejecting function as well as its frequency position. Fig. 6 shows the dependence of antenna's performance on the length (Lvt2) of the vertical strip line elements which are added to the folded T-Shaped structure. The enhanced value of Lvt2 is 1.5mm for our purpose. Fig. 7 shows current distributions over Ant. 3 at the eliminating frequency of 3.6 GHz. It is obvious that the rejecting element's surface current flows in reverse direction of the fractal patch and feedline. Thus the overall effective radiation is very little; as a result rejecting band is achieved. Fig. 8 shows the computer-generated and calculated outcomes of Ant. 2 and Ant. 3. The outcomes show that Ant. 2 covers the UWB range for VSWR ≤ 2.The measured impedance bandwidth for Ant. 2 is 3.1-11.1GHz. and for Ant.3 is 2.94-11.17 GHz excluding stop band. Fig. 9 shows the peak gain for the
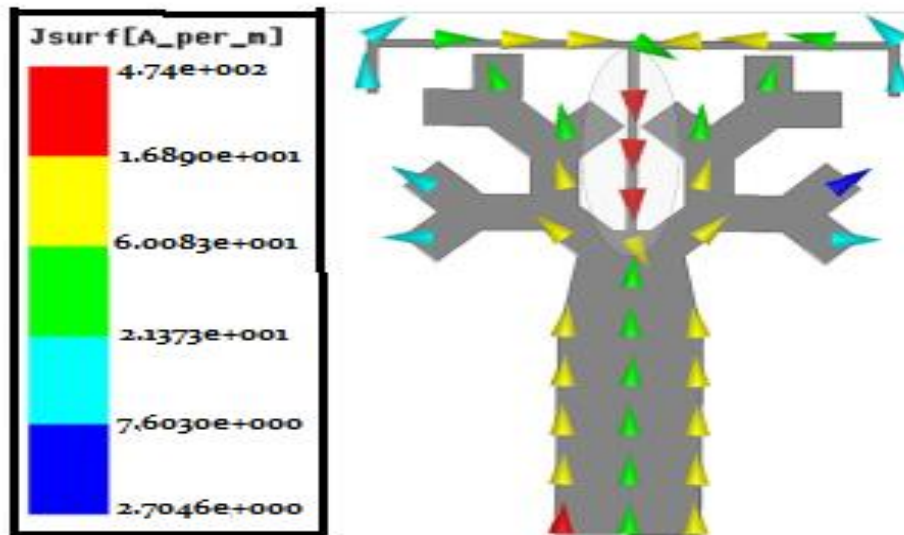

Fig. 7. Distributions of surface currents at notch frequency 3.6 GHz for Ant. d.

Fabricated antennas over 2-10 GHz. The gain of Ant. d falls significantly over the notched band from 3.3-4.2 GHz; however it gradually scales up with increment in the frequency. The measured H-Plane and E-plane radiation patterns of final antenna at 6, 10 GHz are depicted in Fig. 10. Although the   E-plane radiation is two sided, it becomes increasingly unidirectional with increment in the frequency.
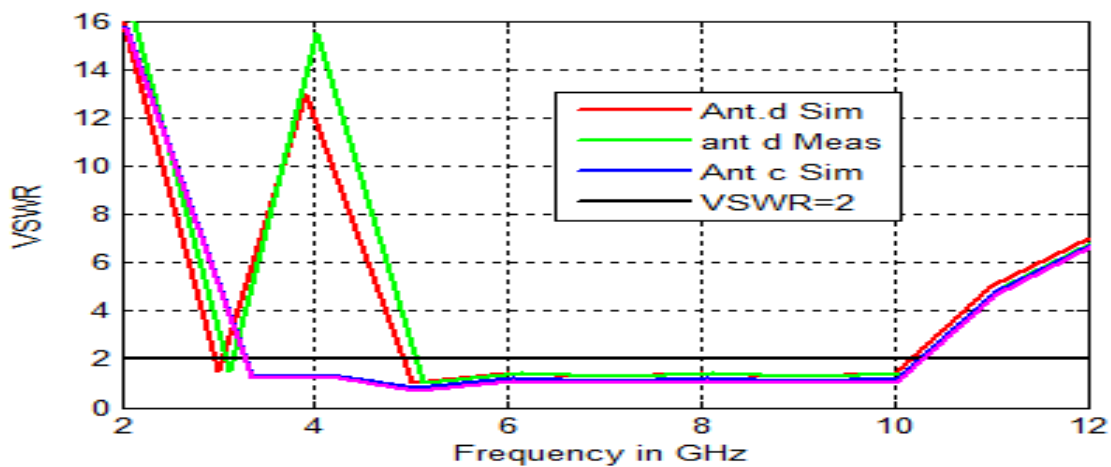

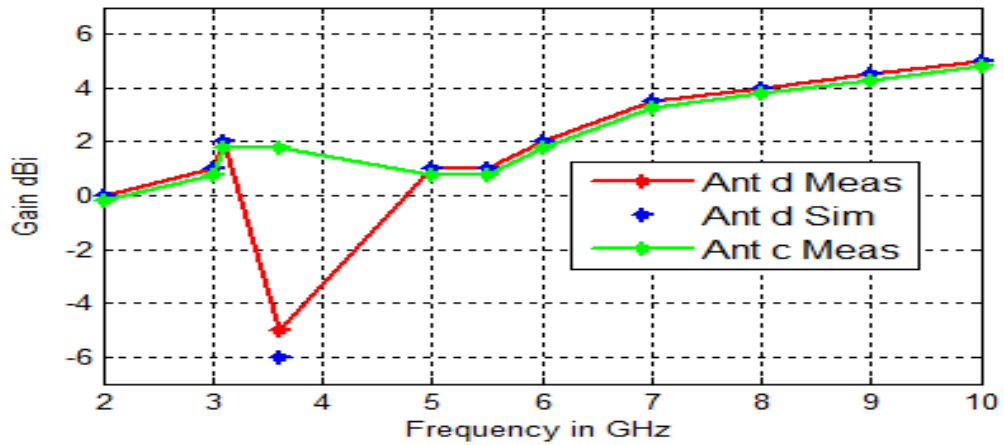Fig.8. Simulated and measured VSWR response for Ant. c and Ant. d.

Fig. 9. Measured and simulated peak gain of Ant. d

In this paper, the gain factor is improved, when compared with the existing systems. Fig. 11 shows the improved gain characteristics of the proposed antenna system.
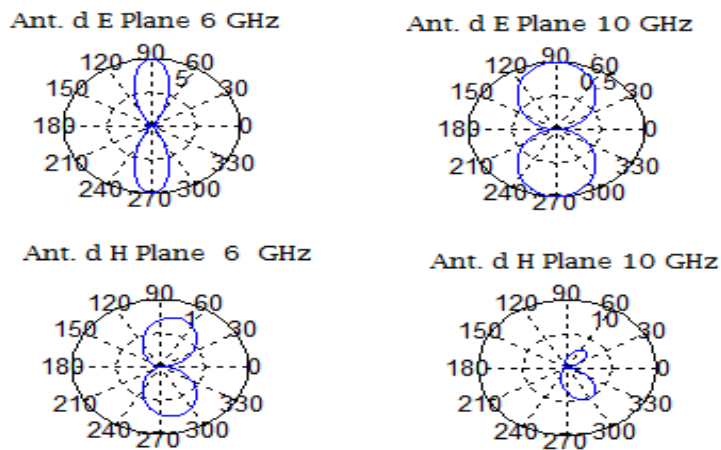

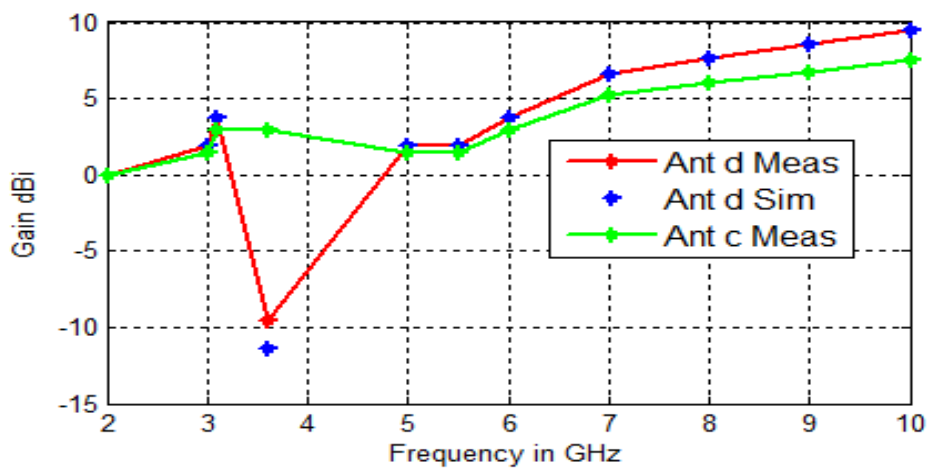Fig. 10. Measured radiation patterns at 6, 10 GHz for Ant. d.

Fig. 11. Simulated and measured improved gain of Ant. c and Ant. d.

IV Conclusion

This paper describes a CPW-fed fractal antenna carrying a folded T-shaped element configuration for achieving band-notch function to hold back interference with existing WIMAX (IEEE 802.16) and C-band systems. The curving in ground plane includes dielectric notches at its side to improve impedance band width of antenna. The proportion of the notches successfully controls the higher and lower band edges of the antenna. The antenna shows unidirectional radiation pattern in the H-Plane in the entire UWB range. The gain factor is improved in this paper than in existing systems. The size of the antenna is $14 \times 18 \times 1 mm^3$.

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