Design of a Wideband CPW Fed Monopole Antenna with Fractal Elements for Wireless Applications

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Abstract: For the exchange of high rate information, wide band antennas are needed and their usage increased tremendously now a days. One of the major challenges in the design of wideband antenna is the design of a small size antenna while providing wide bandwidth, omni-directional radiation pattern and stable gain. The proposed antenna consists of a monopole antenna with polygon shaped patch. Fractal elements are added to the polygon patch to enhance the bandwidth. The ground is extended vertically towards the two sides of the single radiator. The size of the proposed antenna is 25 x 25 x 1.6 mm³ and is prototyped on FR4 substrate whose permittivity is 4.4. The proposed antenna should provide wideband and it is useful for wireless communication applications and it is to be simulated using FEM based Ansoft HFSS.

Keywords: Wideband, Fractal Element, Coplanar Waveguide (CPW), Monopole

1. Introduction:

In 2002, the Federal Communications Commission (FCC) opened the permits of 3.1-10.6GHz frequency band [1] for unlicensed ultrawideband measurements and communication applications with EIPR less than -41.3dBm/MHz [2]. Since then the UWB Antenna, which is the key component of the UWB system is studied and researched widely in the academics and industry. These antennas are used in many applications such as Radars, mobile systems, Biomedical imaging, tracking and they also have the capability of transmitting ultra-short pulses. Among various types of UWB antennas, special attention is given to the printed and planar monopole antennas nowadays since they possess physical features such as small size, low profile, low-cost and ease of fabrication [3].

It is remarkable that, all designs are looking for a wider Commercial UWB system requires antennas with omnidirectional radiation pattern and large bandwidth [4-5]. Recently, many techniques have been presented to enhance the antenna bandwidth which include the Truncated ground plane with use of an L-shaped notch in lower corner [6-7], by increasing the substrate thickness and modifying the radiator, feed structure or ground plane [8-9], and by using an Inverted T-shaped notch in the middle [10]. Different antennas have been designed by using the concepts of Fractals to achieve wideband characteristics [11].

It is a well known concept that the bandwidth of an antenna can be increased by increasing the diameter or thickness of the substrate. This concept is tried here to enhance the bandwidth by increasing the size of the monopole by different sizes and geometries. The direct loading of various simple geometries and iterations were tried as printed monopole. It is theoretically predicted that all geometries upon loading will result in wide band antennas. Slotted
hexagonal is found to be most simple for better parametric control, fabrication, testing and theoretical analysis and hence the investigation is started with hexagonal shape. In this letter, a monopole antenna with polygon shaped patch is proposed where fractal elements are added to this polygon shaped patch to enhance the bandwidth.

2. Antenna Geometry

A hexagonal monopole antenna is the base for this proposed model. Here the monopole is a hexagon of side 'a' on a strip at a distance’d’ from the ground plane. In this case the overall length of the antenna (2.4a+d) is equivalent to the length of the earlier strip monopole antenna. There is a small gap’d’ is introduced to achieve impedance matching.

Fig 1 shows basic model and fractal element model with small modifications in it. Fig 2 is giving clear ideal and model design aspects in iterative manner.
3. Results and Discussion:

Fig 3 shows the reflection coefficient of the antenna with and without fractal element. It is been observed that with hexagonal fractal element antenna is operating in the wideband with bandwidth of 8 GHz approximately. Fig 4 shows the reflection coefficient with variation in the fractal element.

Fig 3 Reflection coefficient for model 1a and 1b

Fig 4 Reflection coefficient of different iterations of hexagonal model

Fig 5 Optimized Fractal Element Antenna model

L=25mm, W=25mm, H=1mm, Lg=11mm, Wg=7mm, g=0.3mm, Wf=2.4mm, Hf=8.95mm, a=8.8mm, b=1mm

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The optimization is carried out for all the controlling parameters studied above. It can be seen that the sizes of the hexagon strip affect the operating frequency. The low operating frequencies decrease regularly with the increasing of 'a', which is similar to a dipole. From fig 6 and 7 the parametric analysis is been observed for change in a and b.

From fig 8 and 9 it is been observed that a bandwidth of 8 GHz is obtained in the desired band with 2:1 VSWR ratio.
The above radiation pattern shows the pattern is almost uniform directional along H-plane and figure of eight along E-plane. Above fig shows the radiation patterns at three frequencies for mean resonant frequencies of the wide band monopole. The antenna has almost identical radiation patterns throughout the 2:1 VSWR bandwidth. Moreover, antenna exhibits cross polar level better than 15 dB in both the planes.

Gain of the antenna measured using gain transfer method is shown in Fig 11. Antenna exhibits a peak gain of 6 dBi in the operating band. At higher frequencies gain is increased considerably due to the slight directional characteristics.

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Fig 11 Peak gains 1.4245 dB at 4.3065 GHz, 3.3495 dB at 7.1206 GHz and 6.0267 dB at 10.5678 GHz

Fig 12 E-Field Distribution at 4.3065 GHz, 7.1206 GHz and 10.5678 GHz

Fig 13 H-Field Distribution at 4.3065 GHz, 7.1206 GHz and 10.5678 GHz

Fig 14 Current Distribution at 4.3065 GHz, 7.1206 GHz and 10.5678 GHz

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It is observed that electric current has been excited by all the fractal elements. The current distribution confirms that the elements are parts of the radiating structure and have created the resonance at 10.5 GHz.

3.1 Slotted hexagonal fractal element monopole antenna

A modified model of hexagonal fractal with slotted structure is proposed here. Fig 15 shows the current model and fig 16 shows its return loss curve with change in ‘C’ value.
A bandwidth of 7.9 GHz is obtained in this case. It is less than 0.1 GHz from the previous case but loss is very less and gain is more compared to previous model.

![VSWR Vs Frequency for proposed model](image1)

**Fig 18 VSWR Vs Frequency for proposed model**

![E-Plane and H-Plane Radiation Patterns at Resonant Frequencies 4.3065 GHz, 7.1206 GHz and 10.5678 GHz](image2)

**Fig 19 E-Plane and H-Plane Radiation Patterns at Resonant Frequencies 4.3065 GHz, 7.1206 GHz and 10.5678 GHz**

The cross-polarization level in H-plane increases at higher frequencies. Minimum difference between co- and cross-polarized patterns at 4 GHz is around 5 dB for 30, 150, 210, and 330. The increase in cross-polarization level is due to the excitation of hybrid current distribution on the antenna radiator at high frequencies.
Fig 20 3D gain for the model at 4.3065 GHz, 7.1206 GHz and 10.5678 GHz

Fig 21 E-Field Distribution at 4.3065 GHz, 7.1206 GHz and 10.5678 GHz

Fig 22 H-Field Distribution at 4.3065 GHz, 7.1206 GHz and 10.5678 GHz

Fig 23 Current Distribution at 4.3065 GHz, 7.1206 GHz and 10.5678 GHz

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The electric current distribution at 4.3 GHz is concentrated on the lower edge of the radiator. This means the antenna lower edge affects impedance characteristic at low frequencies. The current distribution of the proposed antenna is similar to that of the simple antenna. It is seen that the current distribution is more complicated than the first resonance frequency current distribution. The currents excited by the lower fractal elements have strongly affected and improved S11 in the middle frequencies.

**Conclusion:** A monopole antenna with hexagon shaped patch and fractal elements is proposed and designed in this project. The model consists of hexagonal fractal elements attached to the vertices of a hexagon to improve the bandwidth and ground is extended vertically towards the two sides of the single radiator. The size of the proposed antenna is 25 x 25 x 1.6 mm³ and is prototyped on FR4 substrate whose permittivity is 4.4. The proposed antenna model provides wideband and it is useful for wireless communication applications like WI-FI, WI-MAX, WLAN, Bluetooth etc. By introducing a hexagonal slot in the patch, the return loss is reduced which is one of the enhancement.

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**References:**


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