Design of Koch Fractal Bow Tie Antenna for Wireless Applications

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Abstract

The crowding of wireless band has necessitated the development of multiband and wideband wireless antennas. Because of the self similar characteristics, fractal concepts have emerged as a design methodology for compact multiband antennas. A Koch-like fractal curve is proposed to transform ultra-wideband (UWB) bow-tie into so called Koch-like sided fractal bow-tie dipole. A small isosceles triangle is cut off from center of each side of the initial isosceles triangle, then the procedure iterates along the sides like Koch curve does, forming the Koch-like fractal bow-tie geometry, used for multiband applications. ADS software is used to design the proposed antennna. It has covers the applications like GSM, wireless band and other wireless communications.

Keywords—*fractal; koch curve; bow tie antenna; ADS(Advanced Design System);*

I. INTRODUCTION

Designing miniaturized antenna, covering lower spectrum of microwave frequency is a challenging task. Compactness is very important in present wireless communications [2]. The French mathematician B.Mandelbrott introduced the term Fractal and it was used for miniaturiation of antenna and also provide multiband operation which can perform over a single antenna. The term fractal has mainly two important characteristic [1] which provide multiband coverage and compactness of antenna. 1. self similarity and 2. Space filling. By using this functionality these fractal structure can be implemented in any antenna for providing broad band coverage applications.

Several typical fractal geometry are Koch curve, Minkowski curves, Sierpinski carpets, Cantor set and also other fractal shapes are available. In this proposed work, Koch curve has been used in normal bow-tie geometry to implement a Koch like sided bow tie antenna.

For applications that require coverage over a broad range of frequencies, such as television reception of all channels, wide-band antennas are needed [11]. There are numerous antenna configurations, especially of arrays, that can be used to produce wide bandwidths. Some simple and inexpensive dipole configurations, including the conical and cylindrical dipoles, can be used to accomplish this to some degree.

Achieving high gain in a small-size antenna is a very desirable characteristic for many applications [10]. A small element antenna is capable of attaining high gain in a simple structure. These antennas tend to be small, Omni-directional antennas well suited for commercial applications. Examples of small element antennas include Lodges biconical and bow-tie antenna, diamond dipole, ellipsoidal antennas, and Thomas circular dipole.

In radio systems, a biconical antenna is a broad-bandwidth antenna [9] made of two roughly conical conductive objects, nearly touching at their points. Biconical antennas are broadband dipole antennas, typically exhibiting a bandwidth of 3 octaves or more. The biconical antenna has a broad bandwidth because it is an example of a travelling wave structure [7]; the analysis for a theoretical infinite antenna resembles that of a transmission line. For an infinite antenna, the characteristic impedance at the point of connection is a function of the cone angle only and is independent of the frequency. Practical antennas have finite length and a definite resonant frequency.

In order to reach the required bandwidth, a dipole with broadband characteristics is required [5]. There are numerous ways for designing such an antenna. For example: dipole arrays, biconical and cylindrical dipoles can all achieve broadband characteristics. However, dipole arrays have large physical dimensions, and considering the requirement for a small structure, a biconical dipole antenna could be a better choice. Furthermore, the design of a biconical antenna is impractical due to the fact that the shell structure is massive. Instead, an approximation of the biconical antenna, namely a bowtie type antenna, is interesting.

II. PROPOSED ANTENNA

A. Bow Tie Antenna

Because of their broadband characteristics, biconical antennas have been employed for many years in the VHF and UHF frequency ranges.

However, the solid or shell biconical structure is so massive for most frequencies of operation that it is impractical to use. Because of its attractive radiation characteristics, compared to those of other single antennas, realistic variations to its mechanical structure have been sought while retaining as many of the desired electrical features as possible.

Geometrical approximations to the solid or shell conical unipole or biconical antenna are the triangular sheet and bow-tie antennas shown in Figures 1. The triangular sheet has been investigated experimentally by Brown and Woodward [11]. Each of these antennas can also be simulated by a wire along the periphery of its surface which reduces significantly the weight and wind resistance of the structure. The computed input impedances and radiation patterns of wire bow-tie antennas, when mounted above a ground plane, have been computed using the Moment Method [11]. A comparison of the results reveals that the bow-tie antenna does not exhibit as broadband characteristics as the corresponding solid biconical antenna for 30◦< α < 90◦. Also for a given flare angle the resistance and reactance of the bow-tie wire structure fluctuate more than for a triangular sheet antenna. Thus the wire bow-tie is very narrowband as compared to the biconical surface of revolution or triangular sheet antenna.

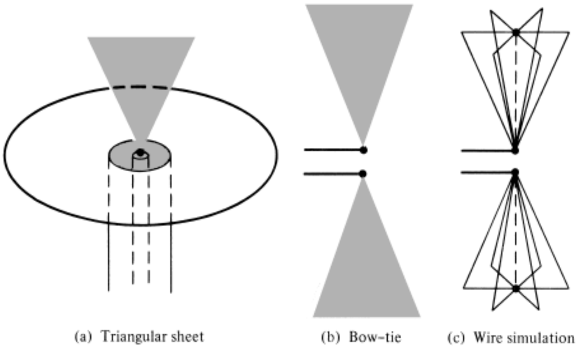

Fig 1: Triangular sheet, bow-tie, and wire simulation of biconical antenna

B. Koch like Fractal

The proposed fractal bow-tie antenna consists of a couple of isosceles triangles with Koch-like sides. A small isosceles triangle is cut off from center of each side of the initial isosceles triangle, then the procedure iterates in the tips of two sides of each angle of the notched triangle while a smaller one protrudes from middle of equilateral sides of each isosceles-triangular notch of last iterative. The iterative procedure itself proceeds, forming the novel fractal bow-tie geometry, as shown in fig 2.

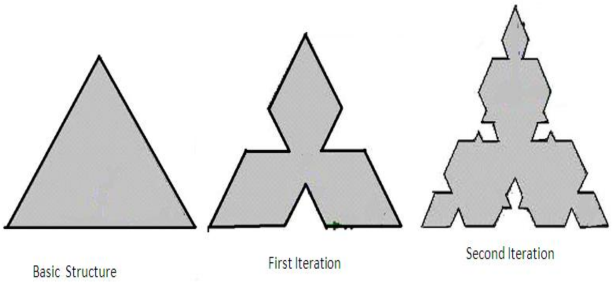

Fig 2: Construction of Koch sided bow tie antenna

III. DESIGN METHODOLOGY

A. Initial Antenna Design

1) Antenna up scaling

Upscaling is done by using [3],

$$\lambda=c/f$$

Where, λ is wavelength, f is frequency and c is speed of light.

2) Flare angle

The flare angle α and the antenna input impedance Zin are related by

$$Z_{in}=120\ln[\cot(\alpha/4)]$$

By varying the flare angle, the input impedance can be varied as required.

B. Design of Bow-Tie Antenna

1) Bow Tie Antanna

The design is initially carried out by normal bow tie antenna using ADS software. The dimension of the antenna is 67.8mm x 38mm. The flare angle of the isosceles triangle is taken as 60 degree.

FR4 substrate material is chosen with a dielectric constant of 4.4. Thickness of the substrate is taken as 1mm. Coplanar strip (CPS) feeding technique is carried out over the entire simulation.

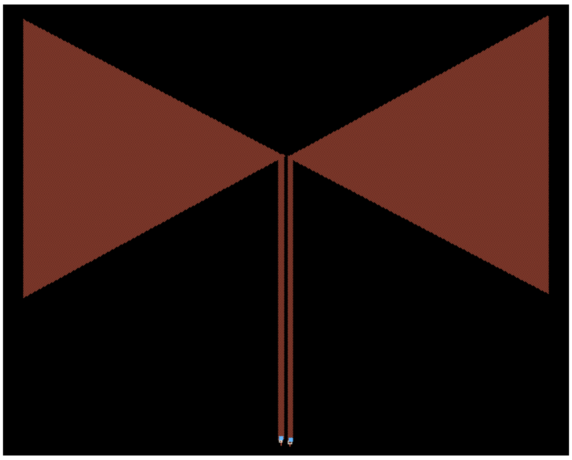

Fig 3: Design of Bow Tie Antenna

The dimension of the feed line is given by 40mm x 0.75mm x 0.5mm (LxWxG). The simulation is carried out by ADS software. The return loss of the above design is shown in fig 3.

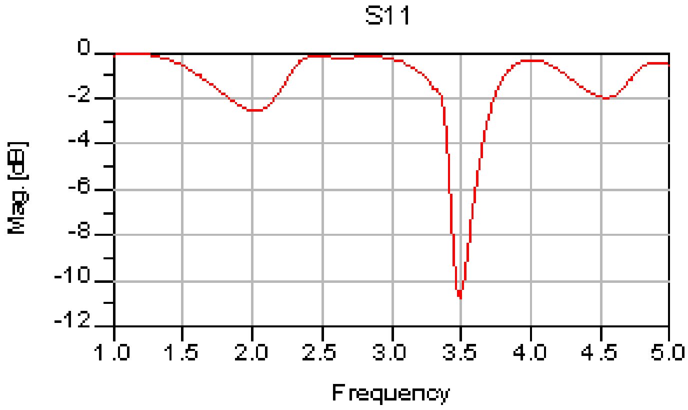

Fig 4: Return Loss of Bow Tie Antenna

The bow tie antenna has operated at 3.5 GHz of -10.8 db return loss. It has the single resonance occurrence. To have a multiple resonance, the concept of fractal Koch curve is implemented in the proposed bow tie antenna as shown in fig 4.

2) *First Iteration of Koch Curve Bow Tie Antanna*

Here the Koch curve is implemented on each side of the initial isosceles triangle as shown in fig 5. To resonate at lower spectrum of microwave frequency, scaling has been done over x axis by 1.4 and y axis by 1.2 on the bow tie antenna.

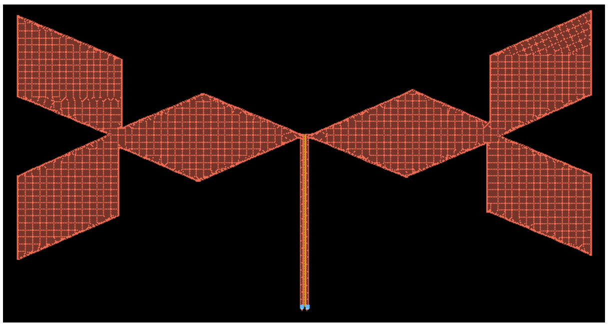

Fig 5: First Iteration of Koch Fractal Bow Tie Antenna

The frequency response of above design is shown in fig 8. The antenna resonates at 2.5 GHz of -14 db return loss, 3 GHz of -18 db return loss and also operates at other frequencies as shown in figure 6.

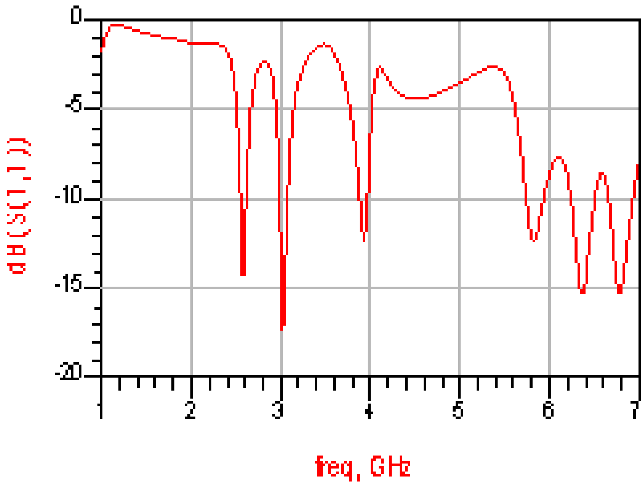

Fig 6: Frequency RESPONSE of FIRST ITERATION KOCH FRACTAL

3) *Second Iteration of Koch Curve Bow Tie Antanna*

Again each sides of the Koch line is further iterated to construct a Koch like sided bow tie geometry. Koch curve is generally constructed by a principle of removing a small portion of triangle at the centre of each side of the initial isosceles triangle as shown in fig 7.

This iteration forms a novel technique of constructing a Koch curve bow tie antenna. Here some small portion of triangle at added along with the sides and some get removed forming the Koch geometry as shown in fig 7.

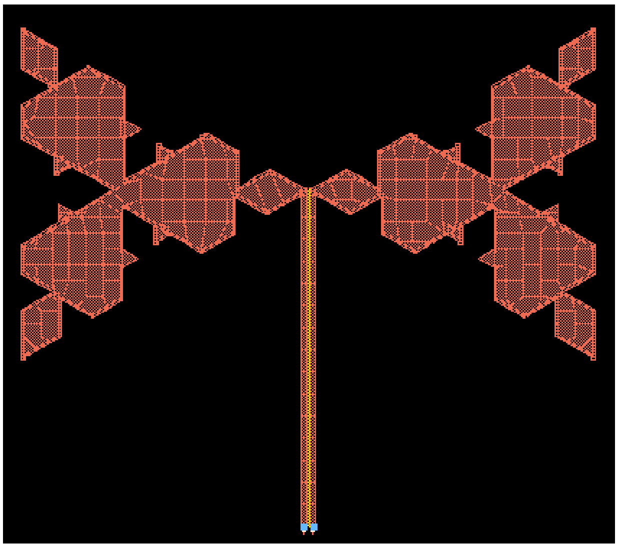

Fig 7: Second Iteration of Koch Fractal Bow Tie Antenna

This second iteration Koch like sided bow tie antenna has resonance as shown in fig 8.

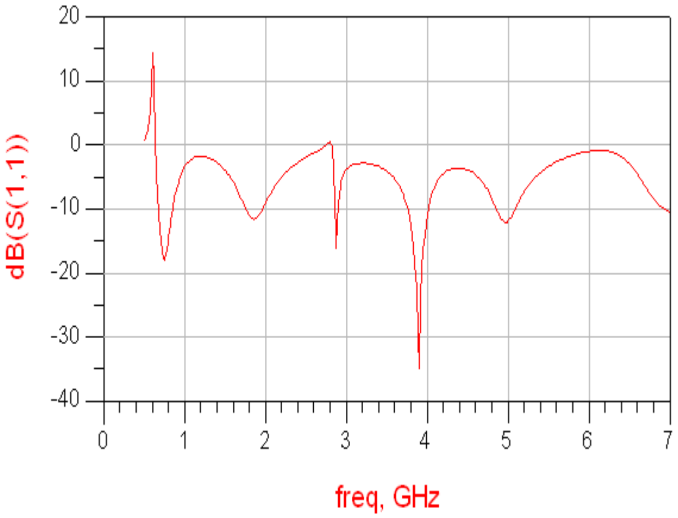

Fig 8: Frequency Response of Second Iteration Koch Fractal

Second iteration of proposed antenna has operate at 1.8 GHz of -10.2 db return loss , 850 MHz of -18 db return loss and 5 GHz of -10.2 db return loss. This has covering the application including GSM upper and lower frequency and also covering wireless application at 5 GHz frequency.

Hence the proposed antenna has designed to operate for wireless band application which covering lower spectrum of microwave frequency. The proposed antenna has covering application like 3.5 GHz of wireless band, 850 MHZ of GSM lower frequency, 1.8 GHz of GSM higher frequency, 5 GHZ of wireless application.

The design is carried out by FR4 substrate with a thickness of 1mm. Coplanar strip (CPS) line feed is used. The dielectric constant of FR4 substrate is 2.2 and thickness of the substrate is chosen as 1 mm is carried out over the entire design.

IV. CONCLUSION

The proposed antenna is designed to operate at lower spectrum of microwave frequency. Koch like sided antenna is designed on the normal bow tie antenna to achieve a multiple resonance in the single antenna has made. Thus, the proposed antenna has cover the application including GSM upper (1.8GHz), GSM lower (850 MHz), 3.5 GHZ and 5 GHz of wireless applications.

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