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Performance and Analysis of a Proposed Quadratic Koch Curve Dipole Fractal Antenna Design

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Abstract: In this study, a novel small size, low profile and multiband quadratic Koch curve dipole antenna is presented. The proposed antenna design, analysis and characterization had been performed using the method of moments (MoM). The new designed antenna has operating frequencies of 359, 936 and 1479 MHz with acceptable bandwidth which has useful applications in communication systems. The radiation characteristics, VSWR and input impedance of the proposed antenna are described and simulated using the 4NEC2 software package.

Key words: Koch curve, fractal antenna, multiband antenna

INTRODUCTION

In the last years of development in antenna area, fractal geometry has given to front of interesting in term of applicability to antennas. Fractals were first defined by Mandelbrot (Falconer, 1990) as a way of classifying complex geometric structures that have non-integer dimensionality and which posses' inherent self-similarity or self- affinity with-in their geometrical structure. These geometries have been used previously to characterize unique occurrence in nature that where difficult to define with Euclidean geometries, including the length of coastline, density of clouds and the branching of trees (Werner and Ganguly, 2003). The fractal antenna is one of their applications which have been demonstrated to enhance antenna properties due to their self-similarity behavior. Multiband behavior for Koch monopole and dipole had been demonstrated in Zainud-Deen *et al.* (2004). This study presents the design and simulation a wire dipole antenna based on the second iteration quadratic Koch curve geometry.

ANTENNA GEOMETRY

Figure 1 contains the first three iterations in the construction of the quadratic Koch curve. This curve is generated by repeatedly replacing each line segment, composed of four quarters, with the generator consisting of 8 pieces, each one quarter long (Fig. 1) (Addison, 1997).

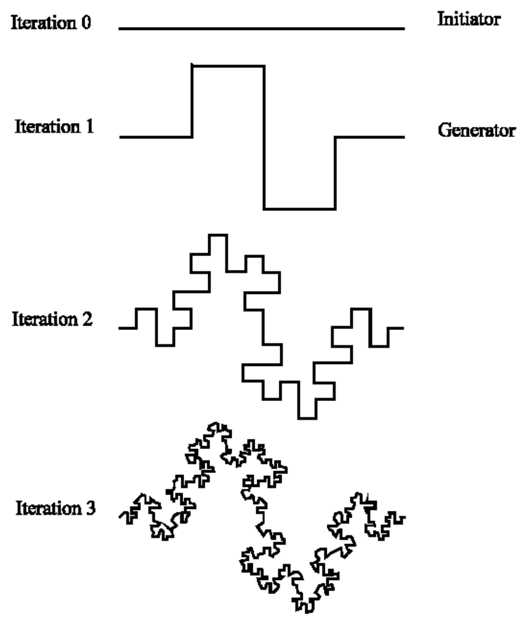

Fig. 1: First three stages of the construction of the quadratic Koch curve

Each smaller segment of the curve is an exact replica of the whole curve. There are 8 such segments making up the curve, each one represents a one-quarter reduction of the original curve. Different from Euclidean geometries, fractal geometries are characterized by their non-integer dimensions. Fractal dimension contains used information

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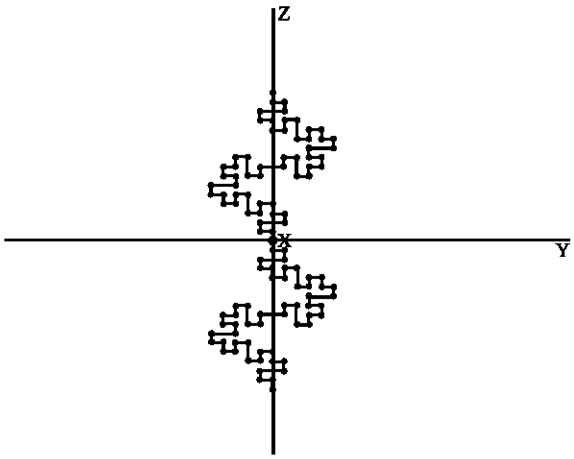

Fig. 2: Quadratic Koch curve dipole antenna

about the self-similarity and the space-filling properties of any fractal structures (Falconer, 1990). The fractal similarity dimension (FD) is defined as (Addison, 1997):

$$FD = \frac{\log(N)}{\log(1/\varepsilon)} = \frac{\log(8)}{\log(4)} = 1.5$$

where, N is the total number of distinct copies and (I\ε) is the reduction factor value which means how will be the length of the new side with respect to the original side length.

Figure 2 shows the second iteration of quadratic Koch curve dipole antenna. The antenna design and simulation have been performed using the 4NEC2 package.

ANTENNA DESIGN

The dipole antenna based on the second iteration quadratic Koch antenna has been modeled, analyzed and its performance has been evaluated using the commercially available software 4NEC2. The method of moment (MoM) is used to calculate the current distribution along the quadratic Koch curve and hence the radiation characteristics of the antenna (Balanis, 1997). The layout of this antenna with respect to the coordinate system is shown in Fig. 2. The modeling process is simply done by dividing all straight wires into short segments where the current in one segment is considered constant along the length of the short segment. It is important to make each wire segment as short as possible without violation of maximum segment length to radius ratio computational restrictions. In NEC, to modeling a wire structures, the segments should follows the paths of

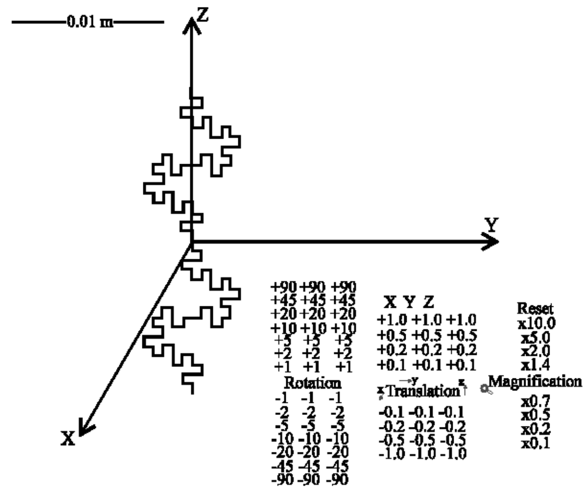

Fig. 3: Visualization of the modeled dipole antenna geometry

conductor as closely as possible (Burke and Poggio, 1981). From this program, the impedance, radiation pattern and VSWR could be evaluated.

The feed source point of this antenna is placed at origin (0, 0, 0) and this source set at 1 volt. The design frequency has been chosen to be 750 MHz for which the design wavelength λ is 0.4 m (40 cm) then the length of the corresponding λ/2 dipole antenna length will be of 20 cm, as shown in Fig. 2.

Figure 3 shows the visualization of this dipole antenna geometry by using NEC-viewer software.

RESULTS

The real and imaginary parts of the input impedance and VSWR of this antenna are shown in Fig. 4 and 5 for a frequency range from 0 GHz-3 GHz in free space with a voltage source of 1 volt.

Figure 4 and 5 show that the antenna has several resonant frequencies. Table 1 shows these resonant frequencies and the corresponding input impedances of each one.

It is clear from Table 1 that, the proposed antenna possesses many resonant frequencies some of which have VSWR of slightly more than two. To achieve matching at the selected frequencies, a suitable matching arrangement is required in the feed used.

The radiation patterns at these resonant frequencies in the planes YZ-plane, XZ-plane and XY-plane have been demonstrated as in Fig. 6, where the antenna is placed in the YZ-plane.

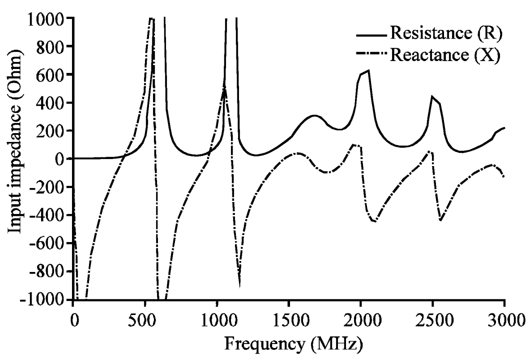

Fig. 4: Antenna input impedance

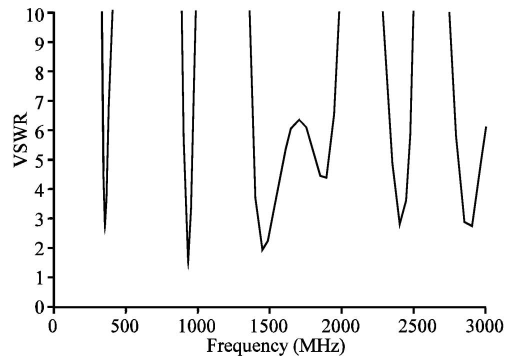

Fig. 5: Simulated 50Ω-VSWR vs. frequency

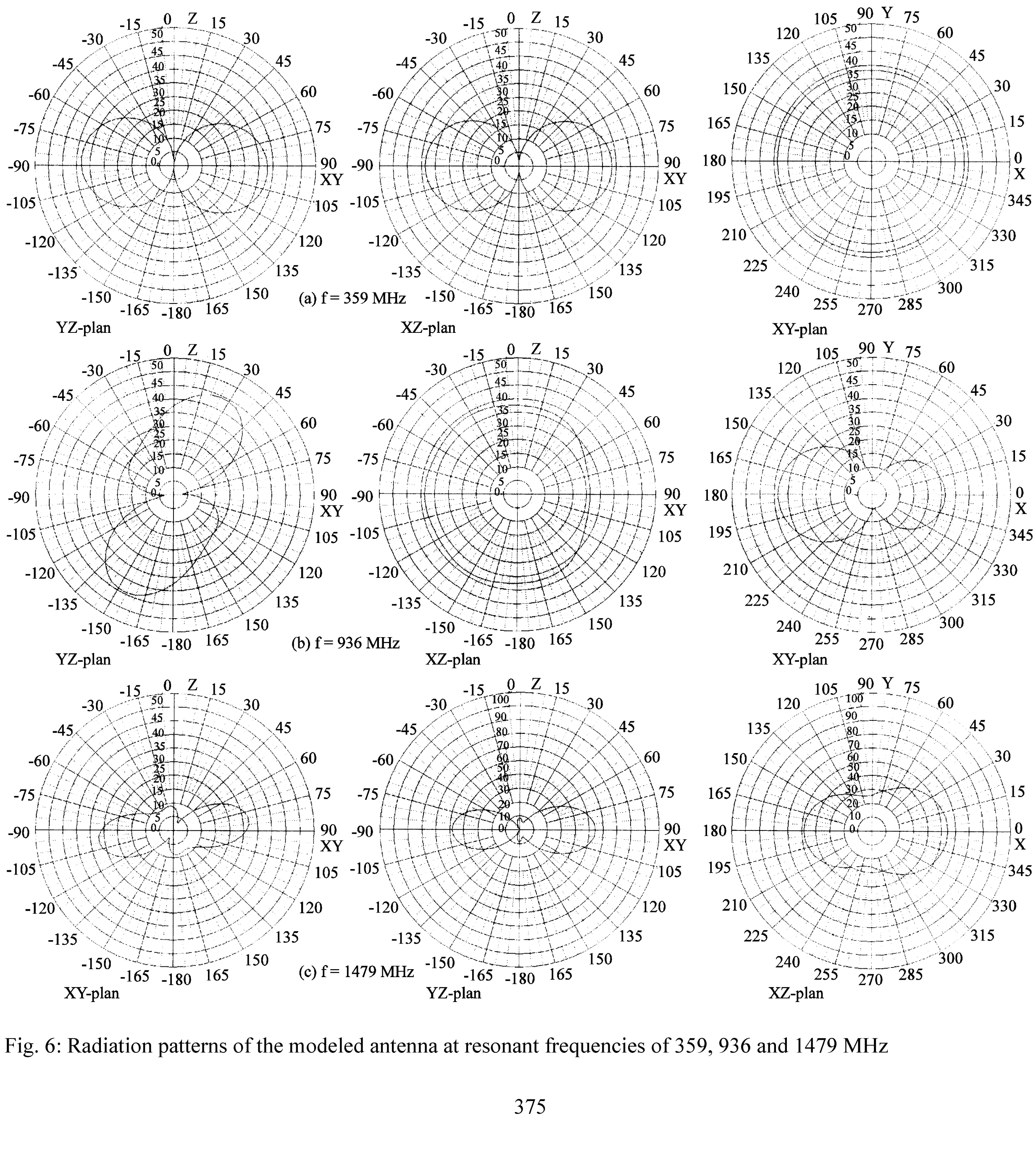

Fig. 6: Radiation patterns of the modeled antenna at resonant frequencies of 359, 936 and 1479 MHz

Table 1: Resonant frequencies and input impedances for proposed antenna

Frequency (MHz)	Input impedance (Ω) R	X
359	19.16	j0.26
936	35.1	j0.63
1479	105.4	-j0.067

CONCLUSION

In this study, the quadratic Koch curve dipole antenna based on the 2nd iteration has been investigated and its performance has been evaluated. Simulation results show that this antenna has a compact size and multiband property. The proposed antenna has three resonating bands at frequencies of 359, 936 and 1479 MHz. According to these frequencies, this antenna can operate as a multiband antenna in the UHF applications. Once optimized for radiation characteristics, this antenna can find many applications in UHF communication systems. It is expected that the proposed antenna can find extensive applications in the modern comp at wireless system after suitable frequency scaling and proper feeding.

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