Analysis and Development of Koch Fractal Dipole Antennas

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Abstract

Devices of mobile communication require smallest sizes of antennas. This is one of the applications of fractal antennas which have reduced size or are multiband and can be used for mobile phone [1], RFID, Wi-Fi, digital TV, among other applications. The term fractal was quoted by the mathematician Mandelbrot in the 1970s, based on some naturally irregular and fragmented geometries that are infinitely divisible with each division being a copy of the whole [2], [3], [4].

The fractal conceit is been used for design antennas. The fractal geometry of Koch allows better space filling, then it is possible to build antennas electrically longer than linear antennas that have the same height, so dipole antennas with Koch curve have lower resonance frequency than linear antennas with the same total height [5], [6], [7].

This paper presents the simulation and development of Koch fractal dipole antennas with 20cm of height, that is, the same linear distance between the first and the last point. The dipoles have zero, one, two and three iterations of Koch, the first element of the series is called K0, the sequential iterations are called K1, K2 and K3.

These antennas were simulated with COMSOL Multiphysics® software, using RF Module, like shown in Figure 1. Due to the complexity, Koch dipole arms were designed in AutoCAD®, then they were imported in COMSOL and defined as perfectly electric conductor (PEC). The complementary structure was drawn in COMSOL, the dipoles were fed by a coaxial lumped port, and the antennas were immersed in a region of free space, bounded by a perfectly matched layer (PML). For the K3 antenna, it is printed on a dielectric substrate due to the difficulty of implementing the geometry on copper filament.

Figure 2 presents the electrical field (V/m) in the resonance frequency of antennas, that are 710MHz for K0, 590MHz for K1, 510MHz for K2 and 420MHz for K3. The radiation pattern simulated in COMSOL also is present in this work.

Prototypes built are shown in Figure 3, dipoles K0, K1 and K2 are made with cooper wire and dipole K3 was made printed on fiberglass substrate. Figure 4 presents the results of S-parameter (S11, in dB) versus a frequency range (350MHz-850MHz) of antennas simulated in COMSOL and measured by network analyzer (Agilent E5071CEP)*, and the smaller the S-parameter value

of the antenna, the better the performance of the antenna.

This work demonstrates that there is a reduction in the resonance frequency when the number of Koch iteration increases, considering Koch dipole antennas with the same height. This characteristic confirms that this fractal geometry can be used for miniaturize antennas. The experimental results were consistent with the simulated results in COMSOL Multiphysics, which demonstrated the efficiency of the simulation method.

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Reference

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Figures used in the abstract

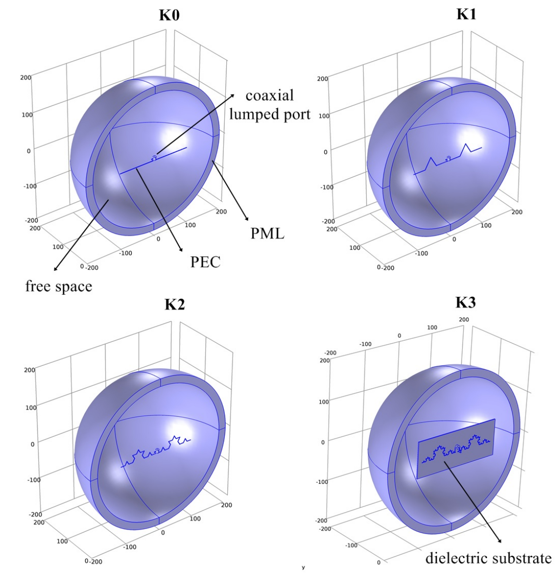

Figure 1: Dipole antennas with 20 cm of height and different iterations of Koch designed in COMSOL.

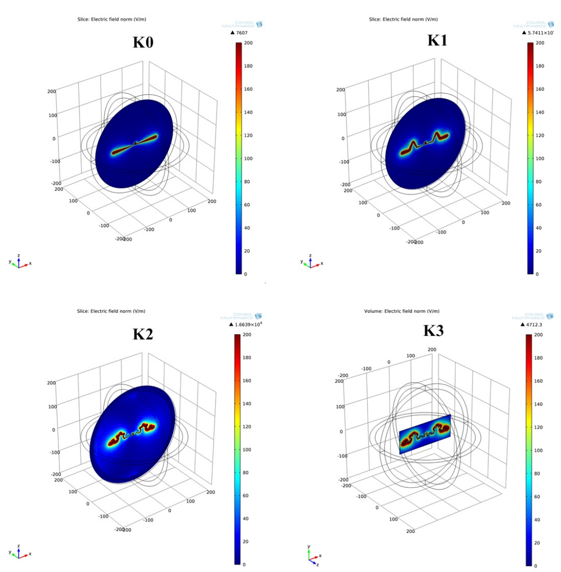

Figure 2: Electric field of dipole antennas simulated in COMSOL.

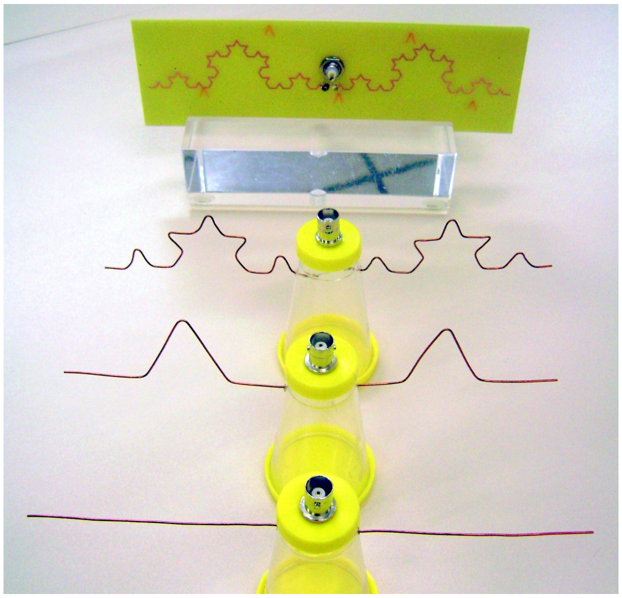

Figure 3: Koch dipole antennas Built.

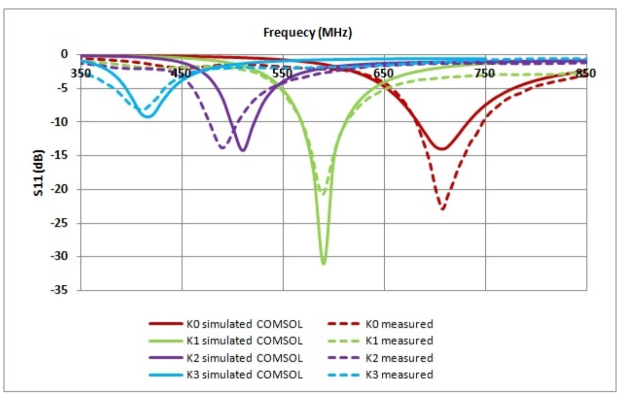

Figure 4: S-parameter versus frequency range of Koch dipole antennas simulated in COMSOL and measured by network analyzer.