Characterization of fractal and space-filling monopole antennas using the box-counting dimension

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In the last years, miniature monopole antennas have received much attention. Such antennas are attractive in environments where space is a constrain factor for example antennas integrated in handheld telephones, watches, $Bluetooth^{TM}$ applications,etc. In other situations, such antennas integrated in vehicles, miniature antennas offer the advantage of easy integrability with other components, aerodinamically performance, avoid thieves from robberies, easy to fix to the mechanical structure, etc.

Among the several techniques to reduce antenna size, namely, reactive loading, top loading mechanism, dielectrics, bending monopole arm, it is the last one that it is discussed in the present paper.

Given a monopole height, it is obvious that if the wire length is increased by bending the monopole arm, resonant frequency decreases, i.e, the antenna becomes electrically smaller. If one takes a straight monopole with the same wire length that such bent miniature monopole, one would obtain a lower resonant frequency. In other words, given a monopole of height h, if it is enlarged two times by bending its wire and at the same time maintaining the height h, the resonant frequency will not be $\frac{f}{2}$ but larger. That means that we need more wire length in order to obtain the same resonant frequency than that of a straight monopole with the same length. Therefore, it seems that bending a wire antenna is interesting because it offers the possibility to reduce antenna size, however, we need more wire length than expected. The question addressed in the present paper is then, is there any geometrical parameter that could help us to know if we need more or less wire length? To solve such question we use the box-counting dimension to study the relation between the geometrical properties of the curve defining the monopole and the resonant frequency [J.Anguera, E.Martínez, C.Puente, E.Rozan, "The Hilbert monopole: a two dimensional wire", Microwave and Optical Technology Letters, vol.36, $n^o 2$, pp.102-104, Jan. 2003]. As an example, Fig. 1 shows three different curves based on fractal geometries each one with a different box-counting dimension.

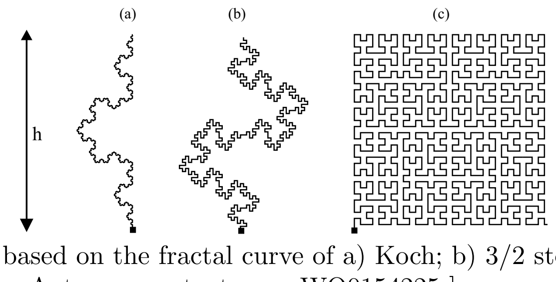

Fig. 1. Monopoles based on the fractal curve of a) Koch; b) 3/2 step; c) Hilbert [Space Filling Miniature Antennas, patent app. WO0154225]