

Three dimensional Space-filling Curve Antennas: Radiation Characteristics and 3D Printing

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Many modern wireless and mobile communication applications require miniaturized antennas. One way of achieving miniaturization is to use conducting traces that follow fractal geometries like those offered by Hilbert and Peano curves. These curves can result in resonant structures with very small footprints that decrease as one increases the iteration order in an iterative filling of a two- or three-dimensional region. The use of 2-dimensional space-filling curve geometries has been previously investigated by many research groups for various antenna, RFID and metamaterial applications. For antenna applications, it has been shown that, through a judicious selection of an off-center feed-point, these electrically small structures can be matched to a 50-ohm line regardless of the iteration order, n , for both Hilbert [J. Zhu, A. Hoorfar, and N. Engheta, IEEE AWPL, 2003] and Peano antennas [J. Zhu, A. Hoorfar and N. Engheta, IEEE AWPL, 2004].

In this work, we have investigated the fundamental radiation characteristics of three-dimensional antennas patterned after various orders of 3D volumetric Hilbert and Peano curves (shown in Figure 1) through an extensive parametric study utilizing numerical simulations. As compared to 2-D Hilbert and Peano curves, 3D versions of these curves provide further miniaturization of a radiating structure. Various antenna properties including radiation pattern, cross polarization, radiation efficiency, impedance bandwidth, and matched-feed locations are studied. Currently 3D printing techniques are being used to fabricate and measure selected prototypes to verify the simulation results. A preliminary 3D printed Hilbert substrate-frame, using polyjet processes, is shown in Figure 2. The details of various alternative fabrication and metallization methods for these 3D antennas together with simulated and measured results will be given in the presentation.

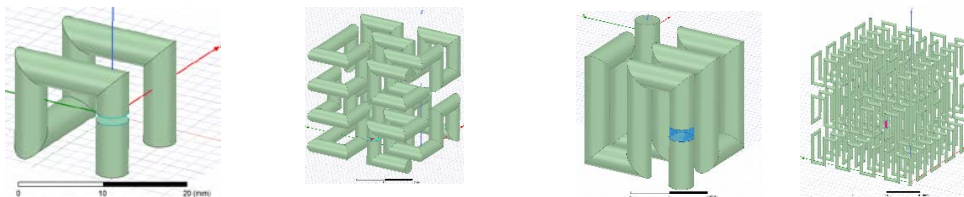


Figure 1: Three dimensional space-filling curves; 1st and 2nd order Hilbert curves (left) and 1st and 2nd order Peano curves (right)

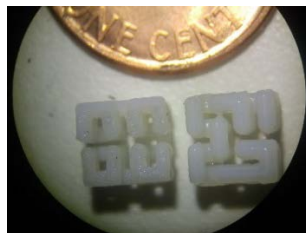


Figure 2: Fabricated 3D Hilbert structures of order 2 for 2.4 GHz operation