

## On the Use of 3D Printing Technology for Electrically Small Antennas

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Rapid prototyping technology, more commonly referred to as a 3D printing (3DP) technology, grows fast and being widely used in engineering and scientific areas. In antenna engineering, the technology is utilized generally in two ways. One is to reproduce the radiation properties of the existent antennas such as horn, patch, reflectarray, only to mention a few, with lighter weight and lower cost. The other one is to design novel antennas pursuing improved radiation properties, a smaller form-factor, flexibility, and so on.

In this presentation, the use of 3DP technology for electrically small antennas is discussed. To be specific, three kinds of electrically small antennas realized by 3DP technology from the authors' institution are introduced. The first one is a folded spherical helix (FSH) dipole antenna made of copper strips. It is found that the electrical size of the well-known FSH dipole antenna (S. R. Best, *IEEE Trans. Antennas Propagat.*, 52, 953-960, 2004) can be further miniaturized while approaching the lower radiation  $Q$  bound using the metal strips instead of the wires. The second one is an electrically small ( $ka=0.276$ ) magnetic dipole antenna composed of multiple folded wires that are packed in an extremely thin dimension of  $0.0016\lambda$ , with the radiation efficiency of 87 %. All the computed expectations are verified experimentally. Considering the antenna structure, these two antennas might be harder to be fabricated without the presence of the 3DP technology. Lastly, the radiation properties and fabrication precautions of a 3D printed, electrically small folded spherical meander wire antenna are investigated. The manual painting of a silver paste is used for the metallization. While the measured efficiency is found to be close to the simulated one, the resonant frequency is deviated by 11.8 % (750 MHz vs. 838.9 MHz). The method to minimize such fabrication error when using the 3DP technology for wire antennas is discussed.

In all, it is the authors' opinion that it is worth to explore the novel manufacturing technology. It could allow more freedom of using the three-dimensional space and would contribute to the innovation of antenna designs. The development of the 3DP and plating technologies are better to be tracked from this point of view.