Characteristic Mode Analysis of Conductive Nanowires and Microwires

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Characteristic Mode Analysis (CMA) has been gaining popularity primarily in the design of antennas in the microwave range, where the structure can accurately be assumed to be a perfect electric conductor (PEC). However, recently the CMA has been adapted for non-perfectly conducting scatterers (A. M. Hassan, F. Vargas-Lara, J. Douglas, and E. Garboczi, IEEE Trans. on Ant. and Prop., 64, 2743-2757, 2016 and Z. T. Miers and B. K. Lau, IEEE Trans. on Ant. and Prop., 64, 2595-2607, 2016). These recent studies show that the CMA of non-PEC structures is an effective technique for determining and explaining their electromagnetic response. In this work, we extend the CMA to a new set of conducting nanowires and microwires of different electrical and magnetic properties.

Since the lengths of these nanowires and microwires are typically much larger than their diameters, we used the Method of Moments (MOM) for Arbitrarily Thin Wires (ATW) formulation to perform the CMA analysis. The advantage of this formulation is that the three dimensional (3D) nanowires and microwires are approximated as a one dimensional wire, with the same equivalent impedance as the 3D structure, which leads to a significant saving in computational complexity. The modes calculated using the MOM for ATW formulation were found to provide excellent agreement with the modes calculated from a commercial MOM solver, where the wires were explicitly simulated as 3D structures.

Using our MOM for ATW formulation, we performed CMA analysis of (*i*) magnetic microwires, (*ii*) nanowires composed of noble metals, and (*iii*) empty and filled carbon nanotubes (CNT). Our simulations show that the material composition of the nanowire has a strong effect on: (*i*) the resonance frequency of each mode, (*ii*) the width of the mode resonance, and (*iii*) the level of overlap between the different modes. These results can be used to quantify the electromagnetic response of nanowires and microwires of various compositions and can also help in selecting the optimum material for each application. Furthermore, we developed an open source graphical user interface (GUI) for easy use of our in-house developed MOM for ATW formulation for CMA analysis. We termed this package “Characteristic Mode Analysis of Conducting Nanowires (CMACNW)”, and it accepts a wide variety of nanowires of different geometries and compositions. The features and the capabilities of the CMACNW package will also be discussed in the talk.