Wave Excitation and Propagation in a Metal Wire Array

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Analysis of wave propagation in a periodic metal wire array has long been of interest because of the structure's unique electromagnetic characteristics. In the 1960s, Rotman first examined wave propagation in a periodic array consisting of infinitely-long metal wires using a transmission-line approach (W. Rotman, *IRE Trans. AP,* 10, 82-95, 1962). More recently, the effective medium description of a metal wire array is introduced and strong spatial dispersion effect is shown intrinsic to the structure (P. Belov et al., *Phys. Rev. B*, 67, 113103, 2003). Based on the effective medium description, wave propagation inside a finite-length metal wire array is investigated by solving a scattering problem with plane-wave incidence (M. Silveirinha et al., *IEEE Trans. AP.*, 56, 405-415, 2008) or by finding a source-free eigensolution (A. Yakovlev et al., *IEEE Trans. MTT.*, 57, 2700-2714, 2009).

In this work, we set to study the problem of Hertzian dipole radiation in a 2-D finite-length metal wire array (also known as the "wire-medium slab"). The radiated field expression is derived using the effective medium approach and found to be in the form of a Sommerfeld integral. Near and far radiated fields are next computed at different positions and frequencies. It is shown that both surface wave and leaky wave can be excited and propagated in the array. The characteristic equation of the wave modes is derived. Propagation constants, attenuation constants and modal field distributions of both mechanisms are extracted and discussed. All results are compared with full-wave simulations and good agreement is achieved between theory and simulation.