Fine Scale Simulations of Patch Antennas with Heterogeneous Substrates

Invited Paper

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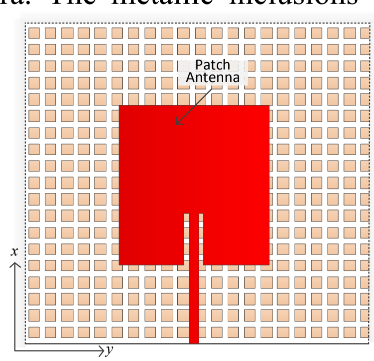
As consumer and industry continue to desire wireless accessibility on an increasing range of platforms, antenna engineers are constantly required to develop new antenna systems which maximize the bandwidth-efficiency to size ratio. One possible method of achieving this is to use artificial dielectrics which allow a greater degree of freedom in the design process by enabling bespoke values of the permittivity. Furthermore, it allows the local permittivity to be varied with respect to the electric fields which can lead to bandwidth enhancements. The authors have previously addressed the idea of creating artificial dielectrics using small scale inclusions embedded in a host medium [Njoku et al. IEEE TAP, Vol. 60, No. 5, pp. 2194–2202, 2012] which contains a detailed literature review.

In this paper, small scale metallic cuboid and spherical inclusions are used to control the effective permittivity of a patch antenna substrate. EMPIRE XCcel Finite-Difference Time-Domain (FDTD) commercial software was used to model the antenna which operates in the microwave spectra. The metallic inclusions were on the scale of 100 microns (see not to scale image). This creates extensive challenges for simulations as many Yee Cells are required to mesh the simulation domain. This is particularly apparent when spheres are used instead of cuboids. The simulations were carried out on a high performance computer with 96GB of RAM and took up to 20 hours to complete. The simulation software allows the dimensions and the properties of the metallic inclusions to be optimized – however, this further adds to the computational requirements.



The conference presentation will show that these intensive simulations demonstrated that the artificial dielectrics had similar effective permittivities as to those predicted by the analytical equations. Simulated efficiency values were also comparable to low loss substrates which indicate that artificial dielectrics may in the future be an advantageous method of designing enhanced antennas. These synthetic materials may be realizable using emerging and future nanotechnology fabrication techniques. Therefore, electromagnetic simulations are currently the optimal approach for understanding the behavior of these complex systems. Future simulations will further reduce the scale of the inclusions.