Dielectric Metamaterial for Antenna Substrates

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At low frequencies, antennas tend to be volumetrically large for designated gain and bandwidth performance. These antennas often also require minimal flexing and bending and are thus limited in their placement in areas on the platform, such as vehicle, soldier uniform, back pack, etc. Furthermore, those areas on the platform are either high loss dielectric material or conducting ground plane which would lower the efficiency of the antenna. Therefore, developing new substrates that help to reduce the antenna's size and shield it from lossy structures and from having reflected fields that cancel the direct radiation, become a field of intense research in antenna community.

The most common approach aimed for miniaturization and substrate height reduction in antenna is to employ high dielectric material. However, it may come at the expense of the excitation of surface waves, resulting in lower radiation efficiency and pattern degradation. Magneto-dielectric material, where magnetic properties are exploited to decrease the impedance mismatch at the air/substrate interface and compensate for capacitive effects, becomes more viable solution than traditional dielectric material solution. To shield the antenna field from impairing effects of conducting ground plane, a high impedance surface is also often used.

Recently, using metamaterials, such as split ring resonators (SRRs), electric-*LC* (ELC) resonator and so on, has been gaining interest for antenna performance enhancement. These resonators are often based on metallic structure and the Ohmic loss at resonant frequency is inevitable. Mie resonances of dielectric particles open a simpler and more versatile route for construction of isotropic metamaterials with higher operating frequencies and lower loss.

In this work, we focus on designing two dielectric metamaterial prototypes. One is high impedance surface used as the ground plane that allows the antenna and its image to radiate coherently without losing efficiency or distorting the pattern. The other is magneto-dieletric material used as a matching substrate and for lowering the antenna profile. In both designs, the dielectric inclusions are made of Barium Strontium Titanate (BST), which is available in powder form and is then molded in desired shape. The proposed prototypes are simulated using commercial full-wave electromagnetic solvers, such as CST, COMSOL or FEKO, to obtain the scattering parameters, *S*. The effective constitutive parameters, i.e. permittivity, permeability and refractive index, are then calculated through a retrieval process. (Amir I. Zaghloul *et al*., First-Principle versus NRW Retrieval of Metamaterial-Insert Constitutive Parameters Using Measured Scattering Matrix, APS-URSI 2018, Boston, MA, July 2018)