Extraordinary Transmission of an Electromagnetic Wave through a Dielectric -Loaded Slot in a Metallic Shield of Finite Thickness

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Metasurfaces have recently been the object of much research, not least because of the large number of promising applications (such as filters, absorbers, beam steerers, sensors and many others). Their smaller size, lighter weight and ability to be conformed to a variety of surface shapes gives metasurfaces significant advantages over others techniques that might be used for the same purpose. One possible application of metasurfaces involves the phenomenon of extraordinary transmission: the strong transmission of a wave through an aperture that is small compared to a wavelength. This has been done in the past using cooperative interference between a large number of apertures in a thick conducting screen (T. W. Ebbesen et al., Nature, 391, 667-669, 1998).
In this paper, we will obtain an analytical expression for the transmission of an H-polarized electromagnetic wave through an infinite dielectric-loaded slot in a metallic screen of nonzero thickness. The problem of an unloaded slot in a screen of zero thickness can be treated using Bethe small-aperture theory, but for finite screen thickness with a dielectric, the problem doesn't seem to have exact solution. L. N. Litvinenko et al. (Radio Eng. Electron. Phys., 22 (3) 35-43, 1977) have formulated this problem using integral equations and mode-series expansions, and obtained an approximate analytical solution under certain limiting conditions. We have modified their approach to handle the case when the relative permittivity of the dielectric loading is very high, so that the slot becomes a partially bounded dielectric resonator. We obtain an analytical expression for the induced voltage at the transmitted side of the slot, from which we can calculate the resonant frequencies where large transmission occurs. The results are compared with those obtained using numerical finite-element simulation software (HFSS) and show good agreement between the two techniques. The success of this simple approximation motivates a deeper examination of the analytical solution and we then attempt to refine it by including effects such as that of higher-order cutoff modes in the parallel-plate waveguide section that is formed by the slot. Results of this extended theory will be compared with those of the previous version and the full-wave numerical simulations.