Full Wave Analysis of Two-Dimensional Periodic Array of Dielectric-Filled Rectangular Windows

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The structure considered in this work consists of a flat perfect electrical conductor (PEC) plate of finite thickness with a two dimensionally periodic array of rectangular windows. The windows are filled with a penetrable, linear, homogenous, isotropic medium with the same thickness as the PEC plate. The structure is excited by a normally incident E-polarized electromagnetic plane wave and the scattering by the structure is solved for in the phasor domain with a time dependence factor $\exp(+j\omega t)$ omitted throughout.

The solution is obtained by first expressing the scattered fields as a doubly infinite series through separation of variables. In order to obtain numerical results the series is then truncated to a sufficiently large finite number of terms and the orthogonality of the terms and the boundary conditions are utilized to obtain a series of equations for the expansion coefficients. The series of equations are then solved through matrix inversion resulting in a finite series that converges to the exact solution as the number of terms increases.

Numerical results are presented in order to demonstrate that the boundary conditions are satisfied along all metallic surfaces and at the junctions between materials. Particular attention is paid to cases where the periodicity of the rectangular windows is smaller than the wavelength of the incident field, in which case the structure is shown to exhibit a frequency selective behavior. This work represents not only a novel frequency selective surface but also a canonical solution which may be utilized in the validation of computer solvers which are often used to analyze more complex periodic metamaterials.