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Numerical Analysis of Glide-Symmetric Metasurfaces with Integral Equations

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Recently, there has been an increased focus of utilizing higher symmetries in metasurfaces for antenna and RF component design [1]. A particular case of higher symmetry is glide symmetry, where the structure is invariant with respect to a mirror and a translation by half-period [2]. When compared to a mirror-symmetric structure, which is invariant with only mirroring, the first two modes join together to close the first stopband. Thus, the dispersion is reduced and the operational bandwidth of the metasurface is increased. Furthermore, the stopband bandwidth is increased. Examples of utilizing these properties are wideband lens antennas [3] and filters [4]. In previous works, the propagation characteristics of such structures are obtained by either commercial software, in-house codes using mode matching [5] or postprocessing procedures in conjunction with commercial software such as multi-modal transfer matrix method (MMTMM) [6]. The development of custom codes is necessary if information on complex modes or attenuation in the stopband is required, as they are currently unavailable from the commonly used commercial software.

In this work, we present an alternative modelling technique for obtaining both real and complex modes of fully metallic mirror- and glide-symmetric metasurfaces. The method solves the electric field integral equation by method of moments. As we are searching for modes in the structure, no external excitation is impressed. The surfaces are assumed to be a perfect electric conductor. They are then discretized and the current is expanded in Rao-Wilton-Glisson basis functions. Then, a homogeneous system of equation is obtained through a Galerkin testing procedure. In computing the coefficients of the system of equations, the Green's function used in simulating periodic structures is traditionally a 2-D array of point sources with a phase shift known as free-space periodic Green's function (FSPGF) [7]. Here, we present a novel Green's function, based on the FSPGF and the generalized Floquet's theorem [8]. By utilizing internal symmetry, we show that we can reduce the size of the problem to only the bottom part of the unit cell. Consequently, the computational effort is reduced. Furthermore, using this function facilitates differentiation between different modes without checking the fields. The application of the periodic Green's function and its common issues, such as accurate integration and acceleration are also presented.

We show the validity of our approach by comparing the results of our code with the established methods. For real modes, a comparison of mesh refinement of our model with CST Studio Suite's eigenvalue solver shows excellent agreement, especially for refined meshes. The attenuation in the stopband for both 0 and 45 degrees propagation is computed and compared with the MMTMM. For both incidences, good agreement is obtained. The novel Green's function presented in this work can be easily included to an existing methods of moments code.

References

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