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Dispersive Analysis of Glide-Symmetric Structures with a Multi-Mode Analysis

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The knowledge of complex wavenumber of Bloch modes in a periodic structure is a fundamental step required to design actual devices. The wavenumber describes the dispersive properties of the structure, i.e. the distribution of pass-bands (guiding-wave type) and stop-bands (EBG type) in the frequency range of interest. While the real part of this wavenumber carries information on phase and group velocities, the imaginary part gives important information about the isolation achieved by an EBG used to decouple different circuits, on losses when working in a lossy pass-band, and on radiation, when radiating power into the surrounding space. However, the attenuation constant is not directly provided by the eigensolver tools of common commercial software. The importance of its calculation stimulates research in the development of methods to perform easily this kind of analysis.

This is particularly true for a specific class of periodic structures, glide-symmetric structures. Glide symmetric structures are periodic structures invariant under a translation of half a period along the periodicity directions plus a mirroring with respect to a plane (the "glide plane"). This corresponds to placing two identical plates with periodic inclusions one in front of the other, and off-shifting them of half the period. This misalignment allows non-dispersive modes over a wideband of frequencies [1], larger stopbands [2], wide-band matching layers in integrated technology [3], wideband anisotropy to compress lenses with transformation optics [4].

These interesting properties motivate the development of new methods to describe these structures. Unfortunately, standard homogenization methods fail when applied to glide-symmetric structures, due to strong interactions between surfaces by means of higher-order Floquet harmonics. The presence of several details at different scales (the gap between the plates is usually relatively small to increase their coupling) slows down numerical methods applied to these structures. Here, we propose a method benefitting of the advantages of commercial software and being capable to recover the complete complex dispersion diagram of a glide-symmetric structure [5],[6]. This method is an extension of the well-known extraction of the Bloch wavenumber from the ABCD matrix of a single cell of a periodic structure described as a two-port network. In the case of glide structures, the ABCD method is usually inaccurate. It can be shown that glide structures require the definition of more modes at each port in order to better describe the interaction between the glide-symmetric scatters.

For this reason, we simulate the scattering parameters of a unit cell by defining several modes on its access ports, and obtain a multimodal S matrix. We convert this matrix to a multimodal transfer matrix by means of simple matrix formulas, and look for the eigenvalues of the structure. If the number of retained modes is sufficient, an accurate dispersion diagram is obtained, with respect to both phase and attenuation constants.

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