Application of the Multimodal Transfer Matrix Method in Dielectric Periodic Structures with Higher Symmetries

P. Castillo-Tapia*, F. Mesa†, O. Quevedo-Teruel*,
*Division of Electromagnetic Engineering, KTH Royal Institute of Technology, Stockholm, Sweden
pilarct@kth.se, oscarqt@kth.se
†Dept. Física Aplicada 1, Universidad de Sevilla, Seville, Spain, mesa@us.es

The Multimodal Transfer Matrix Method (MMTMM) is a hybrid method to compute the propagation constants of periodic structures that combines in-house/commercial software and later post-processing [1], [2]. Its main advantage over commercial eigensolvers is the possibility to find the attenuation constant not only due to material losses but also to electromagnetic bandgaps and/or radiation. However, thanks to the use of commercial software, any complex structure with different materials and/or arbitrary geometry can be analyzed, as opposed to other quasi-analytical and numerical approaches found in the literature such as circuit models [3] or mode matching [4]. The MMTMM models the unit cell of a periodic structure as a multiport network where each pair of ports accounts for a propagative/evanescent/leaky mode in the structure. This means that the coupling between higher order modes is considered in the simulation, which is more accurate in general, and essential in other cases, such as in the study of higher-symmetric periodic structures.

In this work, we propose the use of the MMTMM to obtain the attenuation constant, as well as having a fundamental understanding of two periodic dielectric structures with higher symmetries. A periodic structure possesses a higher symmetry if it is invariant after more than one geometrical operator [5]. Two main spatial higher symmetries can be found in the literature: glide and twist. A glide-symmetric structure is invariant after a mirroring and a translation of half of the period. Differently, a periodic structure possesses twist symmetry after a number N of rotations and translations.

The first structure under study is a glide-symmetric dielectric-filled corrugated waveguide. As previously reported in [6], this structure allows for the propagation of backward modes below the hollow waveguide cut-off frequency. This backward mode was analyzed with a convergence study of the MMTMM to investigate the waveguide modes that contribute to its propagation. The second structure under study is a twist-symmetric dielectric waveguide. In [7], it was reported that the employed three-fold configuration of this structure allows for the propagation of circularly-polarized modes that makes it polarization selective in a specific frequency band. This polarization selection band is characterized with the MMTMM to estimate the losses of both left and right-handed modes.

References

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