Bloch Analysis of Periodic Structures with Higher Symmetries

Mandiaye Fall[(1)], Oscar Quevedo-Teruel[(2)], and Guido Valerio*[(1)]
(1) Sorbonne Université, Laboratoire d'Electronique et Électromagnétisme, Paris, France
(2) KTH Royal Institute of Technology, Electrical Engineering and Computer Science, Stockholm, Sweden

In this paper we propose an equivalent circuit for the unit cell of a glide-symmetric corrugated waveguide. *Glide-symmetric* waveguides (Hessel *et al.*, *Proc. IEEE*, 1973) have recently sparked interest in the Antenna Community for the synthesis of non-dispersive metasurfaces that can be employed to produce ultra-wide band lens antennas (Quevedo-Teruel et al., *IEEE AWPL*, 2016). Other applications involve low-cost and low-loss broadband electromagnetic band-gap for planar integrated circuits (Ebrahimpouri *et al.*, *IEEE MWCL*, 2017).

Here, we focus on the modelling of one-dimensional glide-symmetric corrugated waveguides, i.e. parallel-plate waveguides having corrugations on both plates, which are off-shifted half a period. The modeling of these structures is not an easy task due to the presence of extreme aspect ratios that are required to obtain high refractive index values. Previous work on the subject (Valerio *et al.*, *IEEE T-AP* 2017) has been based on the use T-junction equivalent circuits (Marcuvitz, 1985) to replace the full-wave analysis. However, this previous work is limited to grooves whose widths are smaller than half a period. On the contrary, the circuit presented here is obtained by means of recent studies on discontinuities in waveguides (Molero *et al.*, *IEEE T-MTT*, 2016), and can be formulated by taking into account an arbitrary number of higher-order modes in each region of the waveguide. The circuit can be more easily generalized to larger grooves and possibly to 2-D geometries. This will lead to a circuit description of two-dimensional flat graded-index lenses, avoiding solving a full-wave problem, which are highly computational and time demanding.

As an example of the application of this new equivalent circuit, two dispersion diagrams are calculated by using our equivalent circuit method and full-wave results from *CST Microwave Studio*. Two glide-symmetric structures of the same thickness h_{PPW} = 0.1 mm and period p = 15 mm are considered. A wide frequency band, ranging from 0 to 20 GHz is included in the figures. In both examples, there is a perfect agreement of the results.

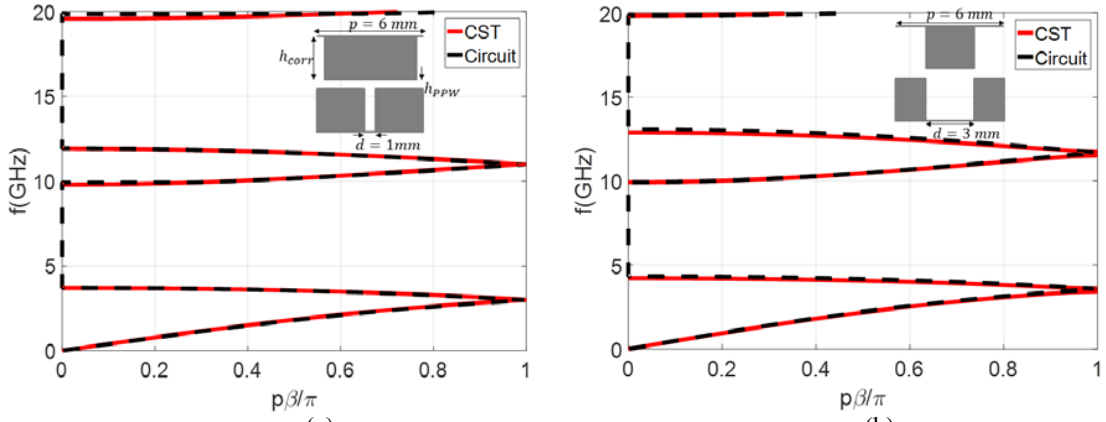

Fig. 1 Comparison between *CST simulations* and equivalent-circuit of the glide-symmetric grooves with p = 6 mm, h_{corr} = 15 mm, and h_{PWW} = 0.1 mm. (a) d = 1 mm and (b) d = 3 mm.