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Hybrid Numerical Method Associating a Conformal Transformation of the Complex Plane with a Matrix Formulation for the Calculation of the Eigenvalues and Eigenvectors in Bended Waveguides

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Abstract— A fast numerical and hybrid method for the calculation of the eigenvalues and eigenvectors of waveguides that present a radius of curvature will be presented in this work, starting from the theory of propagation in electromagnetism resulting from the Maxwell's formalism [1]. This method comprises a so-called conformal transformation (CT) of the complex plane associated with a matrix formulation including a kind of virtual multilayer. The role of the conformal transformation is to avoid the use of the Jacobian transformation and to convert a curved geometry structure into a virtual straight geometry structure presenting an effective and transformed profile of the index structure. Indeed, various mathematic CT exist based on linear, inversion, rotation, homographic or more particular Schwartz-Christoffel transformations [2]. A matrix method, equivalent to those used for real multilayer of materials [3, 4], is directly used into the virtual and new modified profile of CT-index in order to determine the effective propagation constants (or eigenvalues) and the profile of the optical modes (or eigenvectors) propagating in optical guides having a radius of curvature. The numerical codes have been developed and tested in various family structures (with different radii of curvature, different cladding/core index values at fixed wavelength and thicknesses) and asymptotic cases. The results of this hybrid method are in very good agreement with the commercial software COMSOL 3D Multiphysics [5]. The developed hybrid method provides a useful and fast qualitative and quantitative visualization and calculation of the wave propagation in bended waveguides and can be easily compiled on a personal computer.

REFERENCES

1. Snyder, A. W. and J. D. Love, *Optical Waveguide Theory*, Kluwer Academic Publishers, London, 2000.
2. Spiegel, M. R., *Variables Complexes*, Série Schaum, MacGraw-Hill, New-York, 1973.
3. Tamir, T., *Guided-wave Optoelectronics*, Springer-Verlag, Berlin, London, New-York, 1990.
4. Yeh, P., A. Yariv, and C.-S. Hong, "Electromagnetic propagation in periodic stratified media. I. General theory," *Opt. Soc. Am.*, Vol. 67, 423–438, 1977.
5. www.comsol.com.