Eigenanalysis of a tuneable two-dimensional radiating array of wires covered with magnetized ferrite using a curvilinear FDFD method

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Computing of wave propagation and radiation through periodic band gap structures and their unique electromagnetic features attracted a huge research interest during the last decades. These features enabled the development of novel metamaterials and were exploited in frequency selective surfaces, phased arrays and numerous electromagnetic bandgap applications. Moreover, the metamaterials including photonic crystals are extensively investigated in the fields of optics, microwave, and antenna engineering due to their inherent possibility to develop novel devices that may not be found until now, [Huan Xie and Ya Yan Lu, J. Opt. Soc. Am. A **26**, 2009, pp. 1606-1614]. Thus, the analysis and design of such structures have received particular attention which is almost exclusively directed toward the deterministic numerical simulations. Even though this analysis served as a very useful tool, it does not offer the required physical insight, while it does not provide any means to devise novel structures.

Thus, this work elaborates exactly on the eigenanalysis of structures periodic in one transverse dimension and open-radiating from the other, or periodic in both transverse dimensions. Particular attention is devoted to the case of anisotropic media loading, especially ferrites. Band gap phenomena are examined, while non – reciprocal characteristics are under investigation. For that reason, our well established 2-D Curvilinear Finite Difference Frequency Domain (FDFD) method, [G.A. Kyriacou, C. S. Lavranos, P.C. Allilomes, C. Zekios, S. Lavdas and A. V. Kudrin, *URSI – The Radio Science Bulletin*, **344**, 2013, pp. 13 - 31], is combined with Periodic and Open Boundary conditions and this is the next step regarding to our previous work, [C.S. Lavranos, P.C. Theofanopoulos, E. Vafiades, J.N. Sahalos and G.A. Kyriacou, *In the Proc, of LAPC 2014*, pp. 293-297].
In our present effort, the eigenvalue problem is formulated and solved for the eigenfrequencies (ω-formulation) of open periodic structures. Namely, the range of wavenumbers is defined and scanned in an iterative solution procedure yielding the Band diagrams and seeking for backward waves and band gaps. The periodicity of the structure is accounted through the enforcement of Periodic Boundary conditions (PBC) within the FDFD formulation. That yields to transversely infinite periodic 2-D geometries. The periodicity can be either in one or in two dimensions, while propagation is assumed along the third dimension. On the other hand, the open/radiating boundaries are modelled using the Perfectly Matched Layer (PML). Being aware that PML yields to a certain type of pseudo modes and also that some finite element techniques were able to accurately solve eigenproblems using ABCs, we tried to examine this option. For this purpose Mur's Absorbing Boundary Conditions (ABC) are employed next. Using the elaborated method an array of open-radiating periodically located wires covered with axially magnetized ferrites is studied. The interest in this structure stems from our previous analytical study which revealed that such a ferrite-wire-array may support backward surface and possibly backward leaky waves. It is thus expected that a periodic array of these ferrite loaded wires may behave as a backward wave media offering an equivalent negative index of refraction.