DB: Electromagnetic Band Gap Structures and Their Applications

Electromagnetic Band Gap (EBG) Structures: Classifications and Engineering Applications

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Classifications: When natural or synthetic periodic structures interact with electromagnetic waves fascinating phenomena are observable. For example, diffraction characteristics such as frequency stop-bands, pass-bands and band-gaps can be identified. Surveying the literature reveals that various terminologies have been used depending on the domain of the applications. These applications can be found in filter designs, gratings, frequency selective surfaces (FSS), photonic crystals/band-gaps (PBG), etc. Recently a unified classification under the broad terminology of "***Electromagnetic Band-gaps (EBG)***" has been adopted. Ideally speaking, EBG structures are 3-D periodic objects that prevent the propagation of the electromagnetic waves in a specified band of frequency for ***all*** angles and for ***all*** polarization states. However, in practice, it is almost impossible to construct such a complete band-gap structure and frequently partial band-gaps are achieved. Filters typically cover the scalar situation and single angle of arrival. FSS typically cover limited angles of arrival and respond differently to polarization states. PBG typically cover in-plane angles of arrival and also sensitive to the polarization states. FSS terminology has been widely used in the microwave community while PBG terminology has been widely applied in the optical community.

FDTD Computations: To point out some of the unique features of various EBG structures, the FDTD technique with Periodic Boundary Condition/Perfectly Matched Layer (PBC/PML) is employed. The split-field approach is incorporated to discretize the Floquet transformed Maxwell's equations. The inherent broadband analysis of the FDTD approach provides an ideal capbility when the structure is characterized to demonstrate its frequency response. The Prony's extrapolation scheme can further improve the efficiency of the wideband computational technique. The developed FDTD/Prony technique is successfully applied to the characterization of different types of EBG structures.

Applications: The main focus of this presentation is to provide an overview of fundamental properties of various EBG structures such as, (a) FSS structures, (b) PBG crystals, (c) smart surfaces for communication antenna applications, (d) surfaces with perfectly magnetic conducting properties (PMC), (e) creation of meta-materials with negative permittivity and negative permeability, (f) surfaces with reduced edge diffraction effects. Potential applications of these EBG structures are highlighted and future research directions are examined.