Fast Method for Analysis of Electromagnetic Bandgap Structures Used in Power Delivery Networks

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Electromagnetic Bandgap (EBG) structures are increasingly used in high-speed digital and mixed-signal electronic circuits as the efficient means of power/ground noise suppression and port isolation. In order to provide these functions, the EBG structure is incorporated in the power delivery network (PDN) of an electronic circuit. In a conventional method of system implementation, this modified PDN is distributed within the layers of a printed circuit board, whereas in modern microelectronic chip design and system packaging, it can be embedded in the substrate. In all these scenarios, design engineers need to employ fast and accurate methods to account for the added frequency-selective features of the modified PDN in circuit simulations.

Floquet-Bloch theorem has been used for decades to obtain the dispersion equations of periodic structures and thereby to predict the passband/stopband frequencies. Recently, this analysis technique has been adapted to two-dimensional (2-D) transmission-linebased geometries and applied to a number of metamaterials and metallo-dielectric EBG structures to examine their overall modal characteristics. The method can rapidly predict the frequency band diagram. However, it does not include computing complex propagation constants.

In this work, a similar approach is adopted to characterize the PDNs containing EBG structures, as they can be efficiently modeled by 2-D transmission line circuits. Moreover, a general formulation is developed to account for the losses introduced in the network due to imperfect conductors, lossy dielectrics and lumped passive elements representing the series/parallel periodic loadings. The overall incurred loss in signal transmission through such networks is investigated by obtaining the frequency response, H(f). The method benefits from the fact that it is derived from analytical solutions, thus resulting in rapid production of band diagrams with accuracy comparable to fullwave simulators. Furthermore, it has the advantage that frequency is specified as an input parameter and the dispersion equation is solved for the complex propagation constant. Simulation results for a few EBG structures, such as the mushroom-type proposed by Sievenpiper, will be shown to demonstrate the efficiency and capability of the method.