A Simplified Model for Planar Electromagnetic Band-Gap Structures Formed by Metal Patches and Via Holes

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The advantages of Electromagnetic Band Gap (EBG) structures have been utilized in many practical designs of microwave and millimeter-wave components. Their implementation has proven extremely successful in quasi-2D circuits employing microstrip, slotline and coplanar waveguide technologies, or combinations thereof. By periodically perforating the ground plane of a microstrip circuit or, alternatively, adding periodic metallizations on the main circuit level, the excitation of surface waves can be, at least in a relatively wide frequency band, sufficiently reduced and, therefore, the circuit performance enhanced.

For a successful design of periodic structures in a specified frequency range, the knowledge of their propagation characteristics is of critical importance. Once the attenuation per unit cell is calculated, the required number of cells for a given application can be straightforwardly deduced. Therefore, the computation of the characteristics of EBG configurations has recently attracted widespread activity. Full-wave electromagnetic models, both in time and frequency domain, have been developed to increase the accuracy of performance prediction. However, these approaches are often too time-consuming and/or lack flexibility to meet time frames dictated by industry-driven research and development. In order to facilitate a speedy design process of EBG structures, methods involving transmission lines and equivalent circuits are often applied.

Therefore, this paper focuses on a new and simple approach to determine the characteristics of 2D EBG lattices. Based on a specific application requiring a solid, non-perforated ground plane, the model is applied to an arrangement of periodic square metal patches which are connected to ground through via holes or thin wires. The resulting lattice of unit cells is modeled as an array of reactively loaded resonators, which are coupled by a network of fringing and gap capacitances. Below the half-wavelength resonance of the patches, the resonators are reactively loaded and thus form a bandstop circuit for the dominant quasi-TEM microstrip mode.

The practical application of the type of EBG structure is illustrated for a circularly polarized microstrip antenna on a high-permittivity substrate. Reference calculations using a commercially available software package as well as input return loss measurements verify the theoretical treatment of the EBG structure as presented in this contribution.