Input Impedance to Feed a Lattice of Dielectric Scatterers

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Periodic structures, which exhibit the behavior of photonic crystals in the microwave range of frequency, widely known as Electromagnetic Band Gap (EBG) materials, can be profitably employed to focus the radiation emitted by a primary antenna with low directivity. An effective method consists in embedding the primary source in a lattice of dielectric cylinders, tuned to work right above the band gap, where very few lattice modes are allowed [1]. Probe-fed realistic antennas based on this concept suffer from matching problems [2] due to difficult couplings from the guided mode of the coaxial cable to the lattice mode of the EBG and from the latter to free space radiation.

This contribution focuses on the first coupling mechanism in the case of an infinite lattice and derives a closed-form expression that approximates fairly well the input resistance R_{in} of the coaxial feeder at the upper frequency of the band gap. A monomodal situation is considered, assuming that the coaxial feeder excites a single lattice mode, as typically happens in antenna applications. The analytical formula of R_{in} is derived following similar works on probe-fed parallel-plate waveguides: the mode in the periodic structure is expanded in Floquet harmonics, on which the probe current is projected. Figure 1 shows the electric field pattern of such mode in a unit cell of the lattice, obtained including either few or many harmonics in the computation. The functional dependences of the input resistance versus lattice parameters can be satisfactorily reproduced by retaining only a few Floquet harmonics, allowing for a reliable compact expression of R_{in}.

The approximate analytical formula of the input resistance has been validated against the numerical results from (i) the semi-analytical model based on field expansion, run with more than 10^4 harmonics, and (ii) the full-wave solver of a commercial code. Good agreement is obtained. Parametric analyses of the input resistance versus lattice parameters have been carried out with all approaches and the input reactance has been also calculated by means of the full-wave solver. This exploration confirmed the absence of resonances in the input impedance of the coaxial probe and the need of a matching network to feed antennas based on this kind of EBG materials.

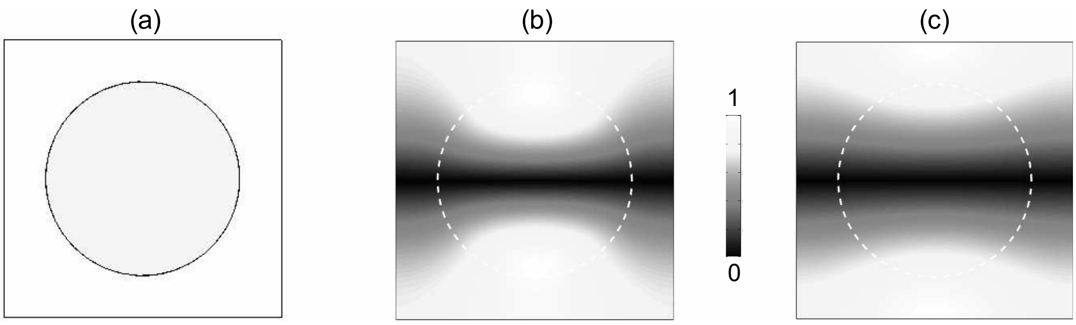

Figure 1. Unit cell of the lattice (a) and normalized E-field patterns at the top of the band gap, as calculated with the rigorous (b) and approximate (c) approach.

References

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