Full-Wave Analysis of Sources within Periodic structures

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Electromagnetic wave interaction with periodic structures has significant renewed interest in recent years. Common analytic/numerical methods including plane-wave (Floquet mode) expansion method, integral equation method, time-domain or frequency-domain finite difference method, and finite element method, are more suitable to purely periodic structures. Periodic structures with localized sources or objects are important in many areas of engineering and science. Examples include undesired radar cross section (RCS) in frequency selective surfaces, radiation degradation in phased array, trapped-wave modes in periodic waveguides, and defects or sources within photonic band-gap structures. The implementation of artificial periodic materials into integrated circuit and antenna structures also results in many new applications.

Up to date, Field analysis of source interaction with periodic structures has not received much attention. In principle, discrete methods such as finite difference or finite element method could provide accurate field solutions. However, from the analysis point of view, it is more advantageous to use a continuous method for infinite structures. The fundamental parameters that characterize the devices can be readily and accurately extracted from the numerical results, in spite of the fact that real physical device must be truncated. In this paper, we overview a double-vector integral equation (DOVIE) method, which is efficient, stable, and accurate. This method applies to general infinite periodic structures with anomalies. The method uses an array-scanning method to find the Green's function for sources within general periodic structures. This approach also provides useful information on the field transition into periodic Floquet mode. Subsequently, the moment method is applied to determine the current distribution over the sources. This approach is a continuous method and its accuracy is similar to typical moment method for canonical boundary-value problems. Several examples are given to demonstrate the applicability of the approach. These include microstrip dipole antennas on a planar electromagnetic band-gap substrate, microstrip lines on a planar periodic structure, and source within corrugated parallel-plate waveguides.