Electromagnetic modeling by embedding using scattering operators

For as much as regards the diode, the experimental statistics consists in measurements of *Vth* and *Gm* electrical performances; after a sensitivity analysis, we have statistically described the Spice model parameters: Is and Rs.
For the IGBT, starting from a statistics related to four electrical performances in various measure conditions, the proposed flow has been applied with the aim of estimating the statistics distribution of the Spice parameters Vt_0 , K_0, V_z and R_{on}

The new proposed flow has allowed us to achieve accurate results and with a clearly inferior computational cost compared to classical approach.

Electromagnetic Modeling by Embedding Using Scattering Operators

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Abstract. Embedding is a technique that has recently been introduced in order to incorporate the presence of an environment in inverse scattering problems, involving sources and receivers on a circular observation contour between the scatterer and the environment. The embedding concept has now been generalized to account for the multiple scattering arising between two disjoint computational domains of general shape containing different objects. This results in a new, larger domain containing the two domains. In turn, these compound domains may be reused to combine with congruent compound domains, or other domains with different shapes or interiors. Thus, quite large structures may be constructed, characterised and stored, and local design modifications will not require the recomputation of the entire structure. Eventually, embedding may be used to evaluate the scattering behaviour of large composite structures, consisting of building blocks that have been characterised electromagnetically at an earlier stage.
Regarding the embedding approach for two objects, the electromagnetic response of one object to an arbitrary source excitation is described in terms of scattering and reflection operators that account for the respective scattering from the object and its environment, which contains the other object. These operators are constructed through repeated application of the equivalence principle to auxiliary problems involving single scatterers in a homogeneous environment. A domain or boundary integral equation is used to solve the auxiliary problems. Subsequently, for each individual building block, equivalent current distributions can be defined that represent the complete field in the presence of the other scattering object. The equivalent current distributions are related via an integral equation of the second kind. Finally, the pertaining equivalent current distributions are used to obtain the scattering operator for the combined structure consisting of the two cells and, if required, to compute the fields inside the combined structure. Once the complete structure is characterised, the resulting scattering operator encompasses already all possible excitations, rendering this technique ideal to study the electromagnetic response as a function of excitation.
To validate the embedding technique, a two-dimensional numerical example is considered in which two hexagonal computational domains are combined with dielectric cylinders as scattering objects. The resulting structure is excited by a line source. For reference, the results are compared with those from a boundary integral equation (BIE) for multiple dielectric objects. To ensure an honest comparison we deploy analytical solutions for the scattered field from a single cylinder to compose the scattering operators of the starting building blocks.
To illustrate the wide applicability of the embedding approach as a design tool for finite size structures, several simulations have been performed, where we evaluate the scattering operator of large composite structures, consisting of building blocks that have been characterised earlier. With Electromagnetic Bandgap (EBG) applications in mind, we have applied this principle to line sources placed in front of an integrated waveguide inside an finite size EBG structure to optimise the coupling with respect to the source location. Since frequencies in the bandgap indicate

resonance effects, multiple scattering plays a dominant role. Although the proof of concept is presented and demonstrated for the 2D case, the theory can readily be extended to a full 3D analysis.

Hybridised PTD / AWE for modelling wide-band electromagnetic wave scattering

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Abstract. Many electromagnetic problems require the solution of large-scale linear systems over a wide frequency band. Areas for which this type of analysis is relevant include scattering by perfectly and imperfectly conducting bodies, Radar Cross Section (RCS) calculation and the analysis of conductor systems. The Method of Moments is frequently employed to solve the Electric Field Integral Equation (EFIE) for such applications. However, it is a computationally intensive process. Repeated formation and solution of the associated matrix equations over a wide band of frequencies may be impractical despite the availability of extremely powerful workstations. To this end, Asymptotic Waveform Evaluation (AWE) was introduced to facilitate quick calculations [1]. In this technique, the electric current is expanded in a Taylor Series around a specific frequency. The coefficients of the expansion are written in terms of the derivatives of the impedance matrix and incident vector. To improve the accuracy of the method, the Taylor series is used to develop a rational approximation via the Padé approximation [1].

In the proposed paper, a novel approach recently developed by the authors [2] will be presented and extended. The surface currents to be computed are oscillatory in nature and as such require high-order AWE expansions if the bandwidth of validity is to be of practical use. In the hybrid method an asymptotic solution whose numerical computation is relatively quick is extracted from the exact formulation to yield a residual unknown which varies more smoothly with frequency. This enables a much lower order approximation to be utilized while still achieving accuracy over a wide bandwidth, resulting in significant computational savings. In our previous work [2] the Physical Optics was chosen as the asymptotic solution. The Physical Optics can be considered as a ′single bounce′ approximation as it does not account for higher order interactions between remote sections of the scattering surface. As a consequence the results presented in [2] are suitable for objects which do not exhibit strong multiple scattering, such as scattering from large smooth flat bodies. To extend the technique so that it explicitly accounts for reflections and diffraction from edges it is necessary to extract a higher order asymptotic solution if the residual unknown is to remain slowly varying over the frequency band.

The asymptotic solution chosen in this paper is the Physical Theory of Diffraction (PTD)[3], which extends the Physical Optics used in previous work [2] by incorporating both reflected waves and fringe waves diffracted from the edges of the body.

The paper will present the hybridised technique in terms of standard Rao-Wilton-Glisson (RWG) basis functions. It will explain how an easily-computed approximate solution can be extracted from the unknown surface current to leave a more slowly varying unknown which can be accurately approximated over a wide frequency band using lower order expansions. In addition to viewing the technique as the extraction of a phase term from a matrix equation based on standard RWG basis functions the paper will explore how it is also possible to consider the technique in terms of a new set of oscillating basis functions, the use of which produce a matrix equation which varies slowly with frequency.