A Novel Hybrid 2D/Q-2D Finite Element Method for Power/Ground Plane Analysis

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Abstract—By realizing the TM_z modal distribution property between the power/ground plate-pairs, the magnetic field actually has only azimuthal components while longitude component is zero. Thus, if the magnetic field wave equation is solved, only a Quasi-2D issue is considered. Furthermore, since the high-order modes are only located in the near region of the anti-pad, thus for the domain far-away from the anti-pad has only the TEM mode. Thereby, in this region, the magnetic field is invariable along the vertical direction, which consequently is a pure 2D domain. As a result, the conventional 3D computational domain is naturally transformed to a hybrid 2D/Q-2D domain, which will significantly reduce the computational cost.

I. INTRODUCTION

The continuously rising clock frequency will cause significant electromagnetic interference (EMI) on the power supply vias crossing the power/ground planes, which could result in significant signal and power integrity related issues. To avoid the design failure at the early stage, it is very necessary to fully understand the related EM issues.

One strategy is based on the equivalent circuit model [1], which the interactions between via, plate, and anti-pad are equivalently represented by suitable coupling capacitors. This type of method is efficient, but could lose of accuracy. Another treatment is on the basis of full wave approach [2]–[3], which is very accurate since the full couplings among massive vias are included. However, the already proposed methods are still computational expensive.

In this work, a novel full-wave finite-element time-domain method is proposed. Based on the 2D and Quasi-2D (Q-2D) field distribution property, the original 3D domain will be simplified as a hybrid 2D and Q-2D domain. Thus, the computational cost will be significantly reduced.

II. METHODOLOGY

For a general power ground plate-pair, it is well known that the domain mode between the plate-pair is TM_z mode, thus the vertical component along the thickness direction of the plate is null, and only the azimuthal components need to be considered. To fully make use of this property, the 3D triangular prism elements are employed as the basic mesh cells. For the Q-2D problem, the unknowns are merely located over the surfaces. In fact, the computational cost can be further reduced since the higher-order modes are highly confined in the proximity of anti-pads. The higher-order modes will be exponentially attenuated along the propagation direction, for region that is far-away from the anti-pad, only the

fundamental mode is required. In this way, the 3D domain will be decomposed into a hybrid 2D and Q-2D domain, which will dramatically make the computation much more cheaper.

RESULTS AND DISCUSSION

To show the effectiveness of the proposed algorithm, a power/ground plate-pair having a rectangular anti-pad is studied. The thickness of the plate-pair is 0.254 mm, and the relative dielectric permittivity is 2.2. The separation distance between the 2D and Q-2D region is equal to the thickness of the plate-pair, namely, 0.254 mm. In Fig. 1, the 2D (blue ones) and Q-2D (red ones) meshes are given. As can be seen, most the meshes belong to 2D domain, specifically, the number of 2D meshes is 4539, and the number of meshes in the Q-2D domain is 1407. The total number of unknowns for the hybrid method is 9718, and the total number of unknowns for the 3D method is 19252. Thus, it is clearly noted that the hybrid method is much more efficient than the conventional one. For the accuracy of the proposed algorithm, we will present them in the conference.

Fig. 1 2D and Q-2D meshes of the power/ground plate-pair.

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