Removing Artificial Resonances in Cropped Structures

Innovation in Accelerated Boundary Element Method Enables Control of Artificial Resonance Effects in High-Speed Channel Models

Resonances from the edges of printed circuit board (PCB) planes and package planes impact the S-parameters of nets on these structures. Typically, such resonances manifest themselves as periodic dips in the reflection and transmission S-parameters of these nets.

A detailed document available from nimbic.com, entitled *Advanced 3D Broadband Boundary Element Methods for Fast and Accurate SI-PI-EMI Solutions* demonstrates why 3D BEM methodology is becoming the method of choice for SI, PI, and EMI.

However, BEM methods have classically encountered challenges when dealing with finite cutout structures. Specifically, the edges of these structures have created additional resonance signature. When cropped subsections are simulated, such as multiple parallel DDR/2/3 lines, additional glitches and oscillatory signature are seen in S-parameters. This effect is particularly pronounced for single-ended parameters, where return current may not be localized. In many cases designers would like to remove these artificially created effects.

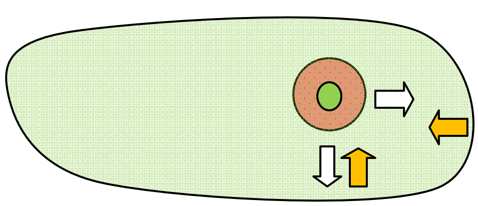
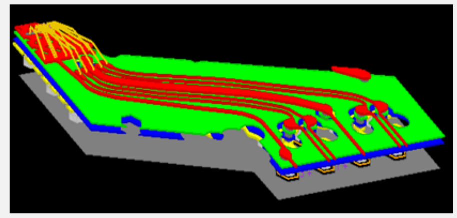


Figure 1: Via structure between two cropped planes generates strong cylindrical wave which is reflected at the cropped boundary. The new ARR suppresses the reflections.



Modeling SI, PI, and EMI in high-speed parallel channels such as DDR/2/3 often leads to cropped geometries. Cropping of power and ground planes is often justified in terms of localized return current paths and also keeps model sizes small and relevant. However, the truncated planes add additional artificial signature to S-parameters through resonances.

While less efficient finite element and finite difference methods may struggle in simulating large structures, they do have the advantage of absorbing boundary conditions (ABCs) in appropriately avoiding such resonances, which boundary element techniques have classically not had.

Nimbic's proprietary solution, artificial resonance remover (ARR), included in nWave, enables elimination of resonance glitches.

nWave relies on proprietary accelerated 3D BEM technology to enable SI, PI, and EMI simulation of RDL and GDS layers, packages, and board sections in the presence of embedded passives and decoupling capacitors. For early design, it is often preferable to simulate relevant cropped subsections rather than entire designs, especially for high-speed channels and applications such as DDR/2/3, PCI-express, Fiber channel, Infiniband, SATA, etc.

The main components in such channels that generate waves and fields that interact with the edge of cropped planes to produce spurious reflections and resonances are vertical vias. As shown in Fig. 1, such vias produce strong cylindrical modes that travel outward until they hit the cropped plane edge where they are partially reflected.

Nimbic's proprietary solution to this artificial reflection and resonance, incorporated into nWave, is based on a new artificial resonance remover (ARR). This modification to the Green's function kernel, within the context of an accelerated boundary element method, creates a local material correction at the cropped boundary, which suppresses reflections in a manner analogous to the ABC in finite element and finite difference methods. With this ARR, users are assured that glitches in single-ended S-parameters from resonances and reflections from the truncated boundary are avoided completely, as shown in Fig. 2. In the case where users are explicitly interested in resonances and reflections from finite boundaries, the ARR can be turned off to exactly simulate finite boundary conditions. As seen in the graph on the right in Fig 2., the differential S-parameters are significantly less impacted by the presence or absence of a finite boundary.

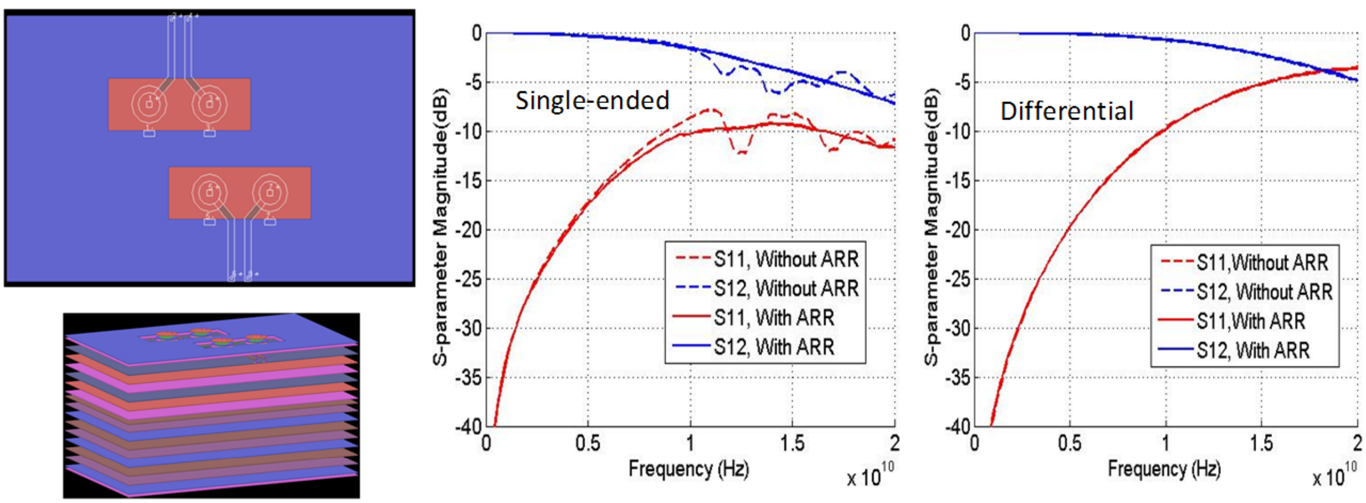


Figure 2: Multilayered via structure with finite plane is shown on the left with large layer-count stackup, and differential excitation. The central graph shows the reflection and transmission single-ended S-parameters. These show significant oscillations or glitches due to reflection from the finite boundary. When the problem is re-simulated with the ARR mode turned on, the oscillations are completely eliminated. As discussed earlier, differential modes have very strongly localized return currents, and as can be seen in the graph on the right, the differential S-parameters are unaffected by the truncated boundary and therefore have the same smooth result with the ARR mode on or off.