Numerical Modeling of Segmented Signal Return Planes

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I. Introduction

Printed circuit board designers sometimes put gaps in ground planes to isolate analog and digital signals. When active traces are routed over gaps in the power and ground planes, the electromagnetic emissions from the board may increase significantly and signal integrity may be degraded [1]. Similarly, when the DC power layer is the signal return plane and high-speed traces are routed across gaps due to log. This summary describes modeling of a simple trace-over-gap configuration. Both experimental and numerical results are presented.

II. Problem Description

As shown in Figure 1, the PCB board under study is 10 cm long, 6 cm wide and 50 mils (1.3 mm) thick. The relative permittivity of the FR4 material is approximate 4.5. A gap is cut in the middle of the ground plane. The gap is 4 cm long and 5 mm wide. An 8.2-cm long trace crosses the gapped ground plane. The trace is terminated at one end by a 47 Ω SMT resistor. An impedance analyzer is used to measure the input impedance at the feeding end.

A hybrid FEM/MoM code (EMAP5) developed at UMR [2] is used to model this problem. MoM is used to model the fields on the surface of the board while FEM is used to model the fields within the dielectric. Triangular elements are used to approximate the surface fields, and tetrahedral elements approximate the fields within the dielectric. Since the fields around the gap area change rapidly, very fine triangular and tetrahedral elements are employed in the gap area while large elements are employed in other places. For this problem, two meshes are used. One is a coarse mesh as shown in Figure 2, which requires 32 Mbytes of computer memory. The other is a fine mesh as shown in Figure 3, which requires 45 Mbytes of computer memory. The same problem is also modeled using EMSIM, a moment method code marketed by Pacific Numerix.

III. Results and Discussion

The measured results are compared with the numerical results obtained with EMSIM and EMAP5 in Figure 4. In EMSIM, a minimal mesh (requiring 75 Mbytes of memory) is used since a normal-size mesh requires 400 Mbytes of memory. The problem is more efficiently modeled using the hybrid approach because the dielectric is modeled using FEM, which requires less computer memory. Figure 4 shows that below 200 MHz, the trace can be treated as a 50-Ω transmission line. When the frequency is higher than 200 MHz, the trace is no longer a 50-Ω transmission line.

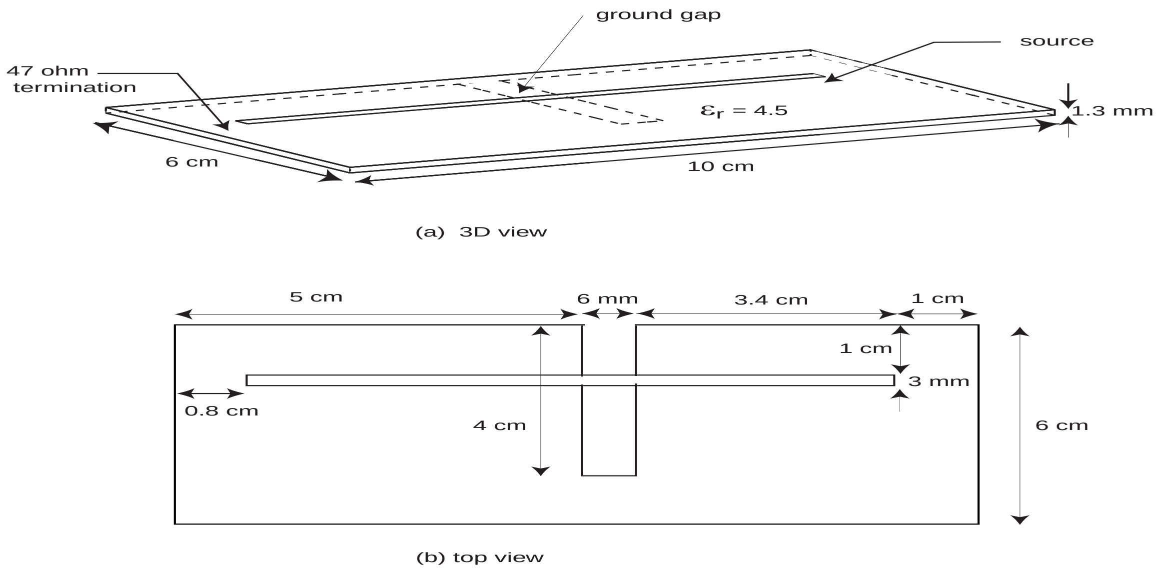

Figure 1. Geometry of a trace crossing a gapped ground plane.

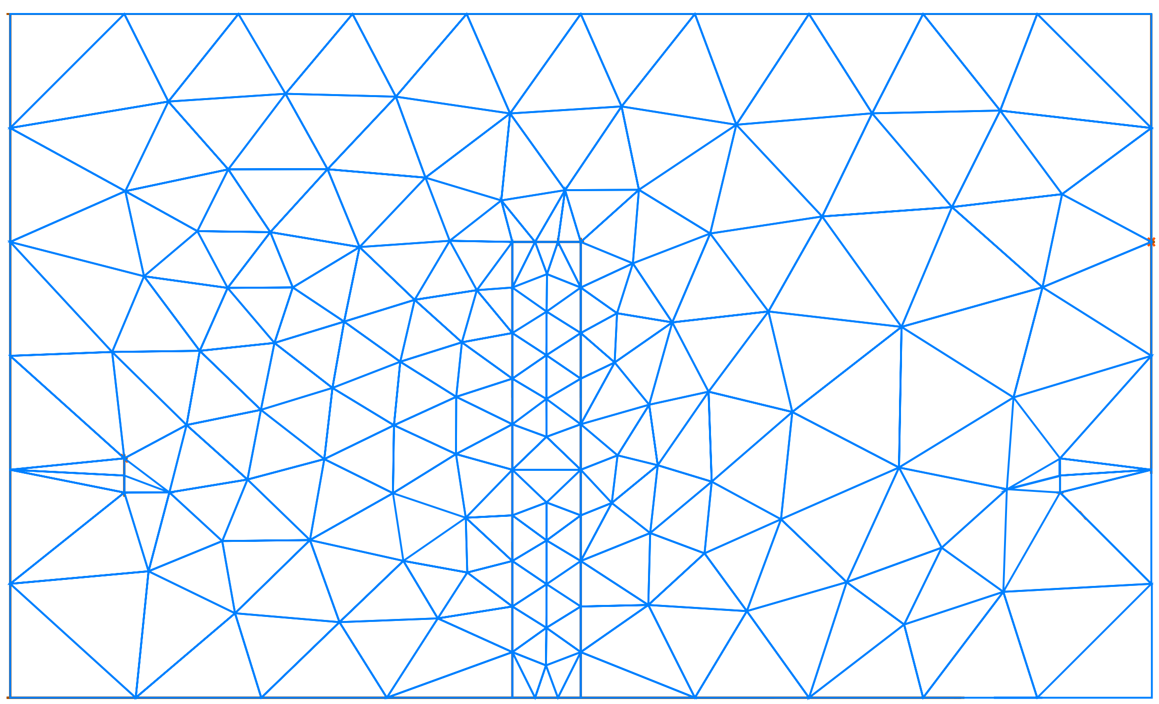

Figure 2. A coarse mesh on the ground plane.

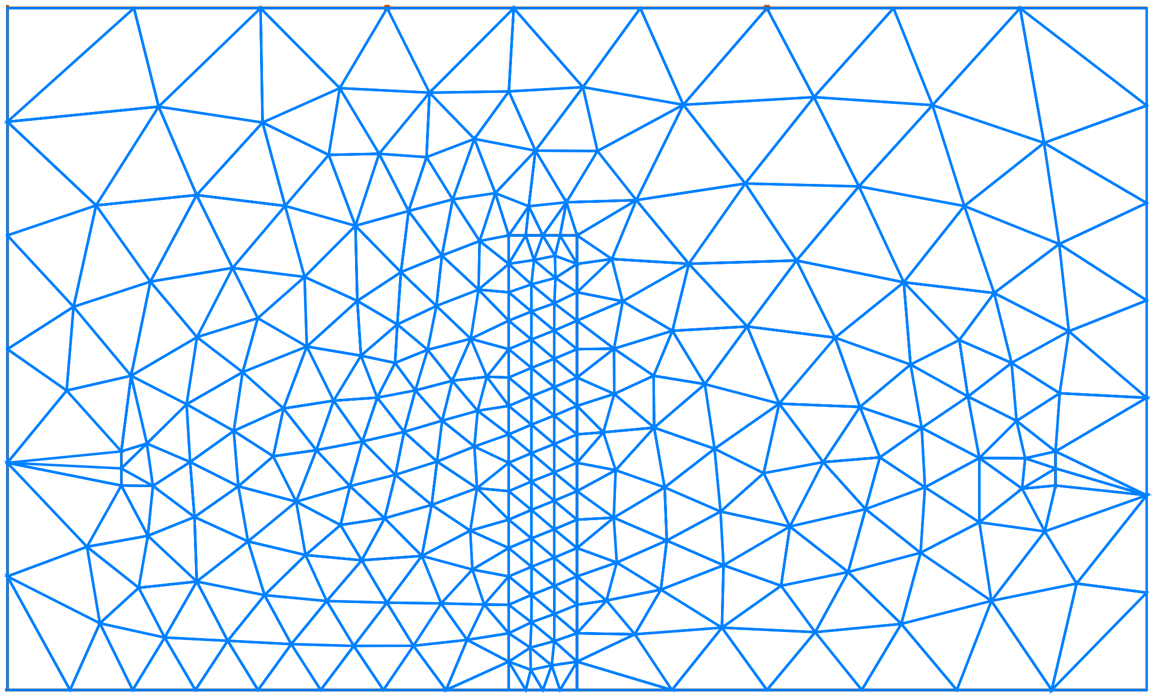

Figure 3. A fine mesh on the ground plane.

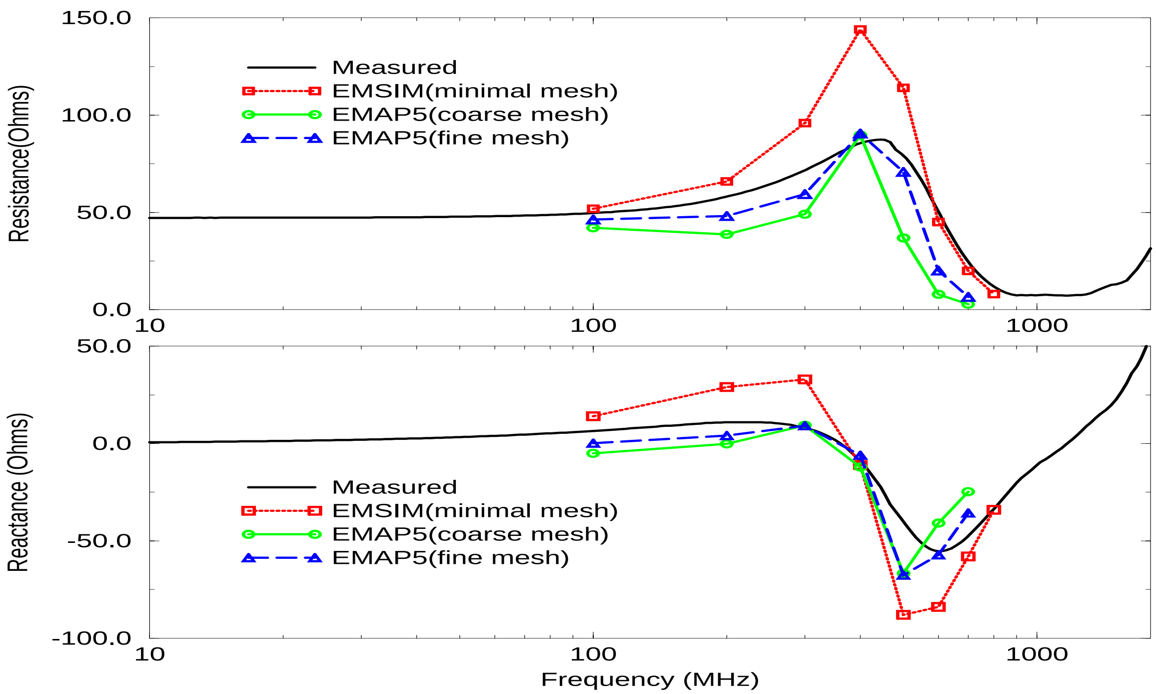

Figure 4. Comparison among measured results and numerical results.

References:

[1] D. S. Britt, D. M. Hockanson, F. Sha, J. L. Drewniak, T. H. Hubing and T. P. Van Doren, "Effects of Gapped Groundplanes and Guard Traces on Radiated EMI", *Proceedings of IEEE International Symposium on Electromagnetic Compatibility*, Autsin, Texas, pp 159-170, 1997.

[2] M. Ali, T. H. Hubing, and J. L. Drewniak, "A Hybrid FEM/MOM Technique for Electromagnetic Scattering and Radiation from Dielectric Objects with Attached Wires," *IEEE Trans. on Electromagnetic Compatibility*, vol. 39, pp 304-314, Nov., 1997.