Modeling EMI Emissions Using Multi-Stage Models

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INTRODUCTION

Technical articles on EMI modeling are becoming more frequent. The range of software packages which claim to perform EMI predications is becoming extensive, and the individual engineer must wade through a significant amount of literature and marketing hype to determine which package can do the types of work appropriate for their application. Fortunately, there are a number of standard real-world EMI modeling problems which can be used to help sift through the various packages.[1,2]

This article discusses the need to use multiple stage models for some real-world problems. The output of the first stage model is used as the input for the second stage model, thus allowing each of the modeling stages to be optimized for the problem at hand. Round pegs need not be forced into square holes, since each modeling stage can use different modeling techniques when necessary.

MODELING TECHNIQUES

There are a number of different full wave modeling techniques. Finite Difference Time Domain (FDTD), Method of Moments (MoM), and Finite Element Method (FEM) are the most popular and useful techniques available in commercial codes. Each of these techniques has strengths, and each has weaknesses; each technique has certain areas it can model effectively, and each has certain areas where it is difficult (or maybe impossible) to model. Luckily, the engineer can overcome these individual technique shortcomings by combining techniques, and using the individual technique only where it is efficient and accurate. The multiple stage modeling approach allows each technique to be used, in turn, to produce the required result for the real-world problem.

Real-world EMI problems are complex, often too complex for a simple single-stage model.

REAL-WORLD PROBLEM

Real-world problems are those that are familiar to most EMI engineers. For example, a printed circuit board (PCB) is placed inside a shielded box, with a connector protruding through the shield, and a long cable attached to the outside of the connector. This could represent anything from a computer system box, to an automotive controller, to a military communications system. It is expected that some of the internal signals present on the PCB will unintentionally couple to the connector pins, be conducted through the shield on the connector pins, and create a common-mode voltage between the outside of the shielded box and the long cable. These common-mode signals will be efficiently radiated by the long cable/wire.

To apply a modeling technique to this problem, the engineer needs to decide which modeling technique best applies. However, there are a number of different aspects of this problem, including PCB layout (with small dimensions), shielding, conducted and radiated coupling, and long wires. No one modeling technique can effectively deal with all these aspects of the problem.

For this example, the overall problem breaks easily into the "inside" and the "outside" segments. The inside of the box, with its PCB, can be conveniently modeled using FDTD. The outside segment of the problem can conveniently be modeled using MoM.

THE FIRST STAGE

The first stage (inside the shielded box) is modeled using the FDTD technique. In this problem, the high-speed data circuits were placed in the back corner (away from the connector opening). The numerous PCB traces/nets were reduced to those either directly involved with the source circuits (high-speed signals), connected to the connector pins directly, or serving as fortuitous conductors between the source area and the connector pin area (Figure 1). The E fields in the connector area are monitored, and are used to determine the common-mode voltage on the connector pins that is due to the current of the source circuit. Since FDTD is a time-domain modeling technique, only one simulation is needed to determine the transfer function between the source and the common-mode voltage across the entire frequency range of interest (30 - 1000 MHz).

THE SECOND STAGE

The second stage (outside the shielded box, including the long cable/wire) is modeled using the MoM technique. The model for this stage is constructed of the outside of the

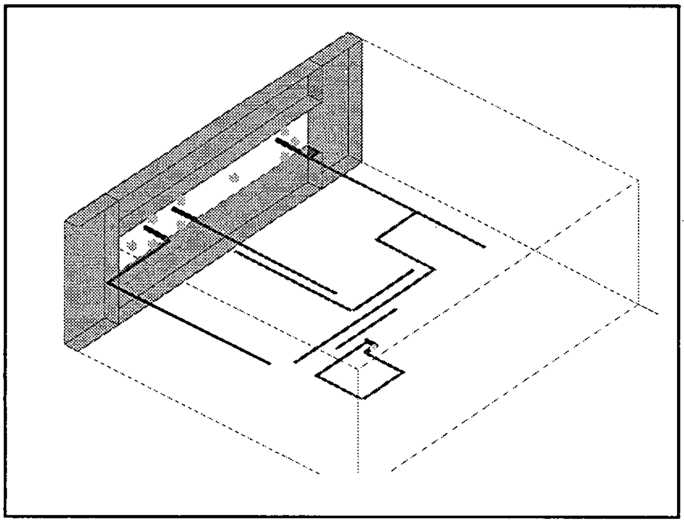

***Figure 1**. PCB Model (Cut-Away View) for Inside Problem (Stage 1).*

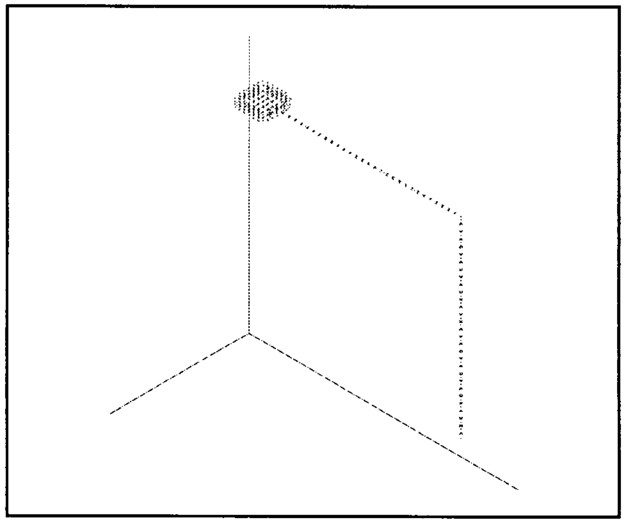

***Figure 2**. Shielded Box with Long Wire Model (Stage 2).*

shielded box and a long wire (which drops to the floor or ground plane at the end). The common-mode voltage found in stage 1 is used as the source and is placed between the shielded box and the long wire. In this MoM model, the shielded box was converted to a wire frame box, and the long wires broken into individual wire segments (Figure 2).

The result of the second stage model is the radiated electric field (caused by the common-mode currents on the structure and wires) at a distance of 10 meters. The maximum E field when the receive antenna was rotated 360° around the model and the elevation scanned from 1 to 4 meters high is directly comparable to the appropriate limit (Figure 3).

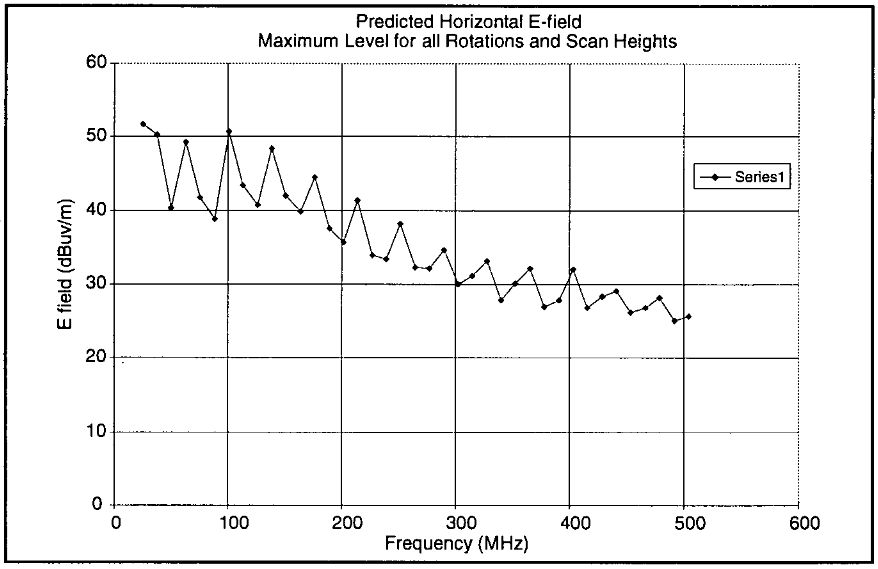

***Figure 3.** Typical Multi-Stage Model (Overall Result).*

SUMMARY

Real-world EMI problems are complex, often too complex for a simple single-stage model. This discussion provides an example of breaking the overall problem into multiple stages and optimizing the individual models for the specific needs of that stage. The output from one stage is used as the input to the next stage, until the final result is achieved.

The usefulness of having a variety of modeling techniques available to the engineer is shown. Multiple techniques are often required for different stages so that the individual models are optimized for the specific task within that stage.

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REFERENCES

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