Hybrid Methods for Efficient Electromagnetic Simulation

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Simulation of the electromagnetic behavior of very general structures is a common activity in many branches of science and technology and many techniques have been proposed and exploited for this purpose. The use of general-purpose time-domain numerical techniques such as the Finite Difference Time Domain (FDTD) [1] and Transmission Line Modeling (TLM) methods [2] is becoming widespread, due to their flexibility and relative ease of use. These techniques offer the flexibility to deal with relatively arbitrary geometries and a wide range of material properties. Unfortunately, the flexibility of numerical simulation tools is often bought at the expense of computational efficiency, both in terms of run times and memory consumption. In particular, their space discretizing nature means that they do not effectively model free-space regions.

Alternative Integral Equation approaches to both frequency and time domain simulations intrinsically incorporate our physical understanding of the relatively simple behavior of electromagnetic fields in uniform spaces [3, 4]. There is no need to terminate the calculation window with artificial absorbers as the kernel of the integral equation intrinsically contains the correct asymptotic behavior at infinity. We will show that such formulations can offer clear computational advantage, especially when the problem space considered contains large uniform regions or the geometry cannot readily be spatially discretized without stair-stepping error.

Having considered these two alternative approaches to electromagnetic simulation we will go on to discuss hybrid simulation techniques, where different simulation tools are used to model those parts of a particular problem to which they are best suited. By embedding a numerical algorithm such as TLM within a global region described by the Integral Equation method, and coupling tools together through a suitable interface, an overall efficiency saving can be achieved [5].

REFERENCES

1. Taflove, A., "Computational electrodynamics: the finite-difference time-domain method," Artech House, Norwood, MA, 1995.
2. Christopoulos, C., "The transmission-line modeling method: TLM," *IEEE Press*, Piscataway, NJ, 1995.
3. Boriskina, S. V. and A. I. Nosich,, "Radiation and absorption losses of the whispering-gallery-mode dielectric resonators excited by a dielectric waveguide," *IEEE Trans. Microwave Theory Tech.*, Vol. 47, 224–231, 1999.
4. Fedotov, F. V., A. G. Nerukh, T. M. Benson, and P. Sewell, "Investigation of electromagnetic field in a layer with time varying medium by volterra integral equation method," *J. Lightwave Technology*, Vol. 21, 305–314, 2003.
5. Lindenmeier, S., L. Pierantoni, and P. Russer, "Hybrid space discretising integral equation methods for numerical modelling of transient interference," *IEEE Trans. on Electromagnetic Compatibility*, Vol. 41, 425–430, 1999.