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Precise Time-Domain Electromagnetic Responses Using Fast Inverse Laplace Transform

S. Ohnuki*, S. Masuda, M. Endo, and R. Ohnishi
Nihon University, Tokyo, 101-8308 JAPAN, e-mail: ohnuki.shinichiro@nihon-u.ac.jp

Time-domain analysis of electromagnetic waves is indispensable for designing optical and plasmonic devices, studying electromagnetic properties of materials, and performing multiphysics simulation of electromagnetic interactions between field and matter. Many commercial softwares based on time-domain solvers have been available recently and they are powerful tools for industrial design and modeling. However, it is still difficult to evaluate reliability and accuracy of the computational results, since reference solutions of time-domain responses are limited.

In this presentation, we will derive highly precise time-domain responses of electromagnetic waves from canonical structures. Compared with our obtained responses, end users can easily evaluate accuracy of their computational results using commercial softwares or own developed codes.

We will obtain precise time-domain electromagnetic responses in the following procedure: rigorous solutions or highly accurate numerical results of electromagnetic waves are computed in the complex frequency s (:= $\sigma+j\omega$) domain. Next, the waves in the complex frequency domain are numerically transformed into the time domain using fast inversion of Laplace transform (FILT) [1,2]. FILT is an error controllable method and the number of digit of accuracy can be strictly evaluated to select the approximate parameter properly.

Time-domain responses of scattered waves from canonical structures are demonstrated for various shapes of the incident pulses and dielectric materials. We will show that computational accuracy of conventional methods, such as the FDTD method, is verified making a comparison with our reference solutions.

1. T. Hosono, "Numerical Inversion of Laplace Transform and Some Applications to Wave Optics," *Radio Science*, vol. 16, pp. 1015–1019, 1981.

2. S. Kishimoto, T. Okada, S. Ohnuki, Y. Ashizawa, K. Nakagawa, "Efficient Analysis of Electromagnetic Fields for Designing Nanoscale Antennas by Using a Boundary Integral Equation Method with Fast Inverse Laplace Transform," *Progress In Electromagnetics Research*, vol. 146, pp. 155-165, 2014.