Accuracy-based Optimization of the Filtered Finite-Difference Time-Domain Method

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The Finite Difference Time Domain (FDTD) method is a technique to solve Maxwell′s Equations for variety of problems in electromagnetism. Even though the FDTD method is flexible, robust and easy to parallelise, it is computationally inefficient in certain cases. Due to the Courant-Friedrich-Levy (CFL) stability condition, a huge number of the FDTD iterations is required when handling fine geometry with the FDTD method, as small spatial sampling (Δs) is needed along with small temporal sampling (Δt). The largest Δt under the CFL condition is Δt_{CFL}. The computational efficiency of the FDTD method can be improved by obviating the CFL stability condition so as to allow a larger Δt, *i.e.,* $N_{CFL} \triangleq \Delta t/\Delta t_{CFL} > 1$. One of the major approaches to realise $N_{CFL} > 1$ is the implicit schemes based on the Crank-Nicolson FDTD method. In the implicit FDTD schemes, the accuracy deteriorates with the increase of N_{CFL}. Thus practically Δt is governed only by the required accuracy. However, the algorithm of the implicit schemes is more complicated than the explicit FDTD method and its coding is not trivial.

Recently an alternative technique has been proposed (C. Chang, C. Sarris," A Spatially-Filtered Finite-Difference Time-Domain Scheme with Controllable Stability beyond the CFL Limit: Theory and Application", IEEE Trans. Microwave Theory and Techniques, 2013). The filtered FDTD method does not change the basic algorithm of the explicit FDTD method but adds a low–pass filter in the spatial frequency domain. When N_{CFL} is larger than 1 in the explicit FDTD scheme, spurious high frequency components are induced. The purpose of the low–pass filter is the removal of such frequency components.

The amount of the high frequency components removed by the low–pass filter has significant influence on the accuracy and the upper limit of N_{CFL} for the stable computation. So far there is little report on the accuracy-based parameter setting for the filtered FDTD method. In the conference, we present our study on the optimisation of the cut–off frequency of the low–pass filter from the viewpoint of maximum N_{CFL} and the accuracy as well as the computational efficiency.