Propagation of arbitrarily high frequencies in the FDTD grid

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The spectrum of the sources used with the FDTD method is in general unbounded. This means that an amount of energy may be coupled to the grid at frequencies higher than the cutoff frequency. This question has retained little attention in the literature, despite its potential impact on the accuracy of FDTD calculations. It is addressed with details in this presentation.

The behavior of high frequencies in the FDTD grid is revisited. Firstly, the FDTD equation of dispersion, previously derived (J.B. Schneider, Ch.L. Wagner, IEEE Micr. Guid. Wav. Let., 1999) up to frequency ½ Δt, where Δt is the FDTD time step, is extended to any higher frequency. Secondly, the phenomenon of aliasing resulting from the sampling of space and time, which was addressed in a special case in the past (L. Gürel, U. Ogul, IEEE Trans. Ant. Propag., 2000), is analyzed with details in the context of general sources. All this permits the explicit understanding of what occurs when arbitrary high frequencies are present in the spectrum of the enforced sources. In particular, this shows that the energy of some frequencies higher than the mesh cutoff can propagate in the FDTD grid without dissipation. And because of the aliasing phenomenon, this energy may pollute the frequencies below the cutoff, i.e. the frequencies of interest in FDTD calculations.

Numerical experiments are shown to illustrate the propagation and aliasing of the high frequencies in the FDTD grid. And some recommendations are provided on the choice of the spectrum of the sources in view of removing, or at least reducing as much as possible, the spurious effects of the aliasing phenomenon on the accuracy of the FDTD calculations.