Numerical assessment of the combination of subgridding and PML grid termination in FDTD

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Together with the Finite Element (FE) and the Boundary Element method, the Finite Difference Time Domain (FDTD) method is one of the well-established numerical techniques to model a very broad category of electromagnetic problems. In order to be able to efficiently include the finer geometrical details, subgridding is used to avoid the use of a fine mesh over the whole region of interest. In his PhD (*"H-, P- and T-refinement strategies for the FDTD-method developed via Finite Element principles,"* Ohio State University, 2008) and papers based on it, Chilton provides a systematic framework for the introduction of general subgrids based on FE principles. The subgridding approach used in our work is an extension of this approach.
A crucial element of the FDTD-method is the termination of the grid in an absorbing boundary condition (ABC). With the invention of the Perfectly Matched Layer (PML) by Bérenger in 1994, this PML is now the de facto standard ABC allowing very low reflection, even when positioned close to scatterers. However, PML updating equations are computationally more expensive than the standard update equations and several layers of PML cells are needed.
In this contribution, also the PML is first included into the overall subgridding framework proposed by Chilton. Next, the following important question that has not been studied yet, arises: is it useful to apply subgridding to the PML and more importantly, how does subgridding in the problem space and (subgridded) PMLs interact. To this end, three types of subgridding are considered: normal subgridding, i.e. subgridding in the direction perpendicular to the PML interface; tangential subgridding, i.e. subgridding in the directions tangential to the PML interface and a combination of both. We numerically investigate the effect of combining any of these subgridding types with a subgridded problem space. By determining the reflection of the field of a point source caused by the PML, it becomes possible to not only determine the general reflection level, but also to pinpoint the precise source of the reflections, as such allowing to clearly establish the effect of the different subgridding strategies. The conclusion of this study is that important reflections are found originating from the corner points of the PML (as expected) but these reflections worsen when grid non-uniformities are present due to subgridding. Hence, the combination of subgridding and PML should be handled with great care.