A NOVEL APPROACH FOR TIME-DOMAIN ELECTROMAGNETICS

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The evolutionary approach to electrodynamics (EAE), which was recognized as an alternative to the classical time-harmonic field method, has been instrumental in advancing our understanding of electromagnetic fields in the time domain [1]. Nonetheless, previous research on the EAE has primarily focused on electromagnetic fields expressed in standard SI units, which has somewhat limited the examination of mechanical properties such as mass and inertia. Building on the theoretical framework of Kaiser [2], this study introduces a novel approach that represents electric, $\vec{\mathbb{E}}(\mathbf{r},t)$, and magnetic, $\vec{\mathbb{H}}(\mathbf{r},t)$, fields using the inverse meter unit, $\lfloor 1/m \rfloor$ [3]. This representation unifies the physical dimensions of $\vec{\mathbb{E}}$ and $\vec{\mathbb{H}}$, enabling a more comprehensive and universally applicable analysis.

Recent publications that explain the mechanical properties of waveguide electromagnetic fields and provide a different approach for the perfectly matched layer (PML) technique of the finite-difference time-domain (FDTD) method were presented [4, 5].

The FDTD method [6] often faces challenges when dealing with problems in unbounded domains, particularly in wave-structure interactions. To address this issue, the PML technique [7] can be used to implement an absorbing boundary condition (ABC). The proposed technique effectively absorbs outgoing waves without causing reflection, thus improving the accuracy of free-space simulations while reducing computational requirements.

In this tutorial lecture,

1. A novel format of Maxwell's equations where electric, $\vec{\mathbb{E}}(\mathbf{r},t)$, and magnetic fields, $\vec{\mathbb{H}}(\mathbf{r},t)$, have the same unit, $\lfloor 1/m \rfloor$ will be introduced.
2. Modified EAE in SI Unit System will be presented.
3. Energetic and mechanical properties of waveguide modes will be presented.
4. Advantages of the novel format of Maxwell's equations, where the dimensions are aligned, and a more symmetric framework for the PML within the FDTD simulations will be discussed.

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