Fundamentals of the FDTD Technique & Major Features of Its Implementation in *QuickWave-3D*

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Keywords: computational electromagnetics (CEM), finite-difference time-domain (FDTD) method, conformal meshing, irregular meshes, field singularities, co- and post-processing, computational efficiency.

The lecture is designed as a collage of fundamentals of the FDTD modeling, rigorous mathematical investigation of its numerical accuracy in various simulation scenarios, and a review of practical applications for high frequency circuits, antennas, and heating devices. The FDTD method is also classified in the context of CEM methods in terms of the underlying philosophy and the required computer efforts. On-line simulations with *QuickWave-3D* software are performed to illustrate the theoretical concepts and to validate the maturity of conformal FDTD for microwave and optical research and industry.

The constellation of topics considered in the lecture material includes:

1. 1D, 2D, and 3D FDTD formulations in the Cartesian coordinate system.
2. Mathematical studies of stability and accuracy:
    - numerical dispersion relations – Courant stability criterion and error bounds,
    - numerical dispersion relations in lossy media,
    - numerical effects on irregular FDTD meshes,
    - conformal meshing – advantages and challenges,
    - modeling of field singularities.
3. Excitation models:
    - point sources,
    - modal templates,
    - free-space illumination.
4. Extraction of engineering parameters from the FDTD filed simulations:
    - *S*-parameter definitions and extraction,
    - radiation patterns,
    - eigenvalues.
5. Concluding remarks:
    - performance of contemporary FDTD (problem sizes, RAM and CPU requirements),
    - directions in the FDTD research,
    - methods of software and hardware acceleration.

The specific topics for this lecture are adjusted to the audience interests and background knowledge of the subject.