OS7201 Electromagnetic Optics Analysis Using Finite-Difference Time-Domain Method
Fall 2022

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Class Schedule Mon. 17:00 – 17:50 and Tus. 14:00 – 15:50 in IL-112

Office Hours Tue. 11:00 - 11:50 or by Appointment

Prerequisite Undergraduate level of Vector Analysis, Engineering Mathematics, and Electromagnetics.

Textbooks

1. Video lectures of "Electromagnetic Analysis Using Finite-Difference-Time-Domain" by Prof. Raymond C. Rumpf of University of Texas at El Paso. They are available on https://www.youtube.com/watch?v=KHTByojnsZE&list=PLLYQF5WvJdJWoU9uEeWJ6-MRzDSziNnGt

   The corresponding lecture notes can be found on https://empossible.net/academics/emp5304/

2. Lecture notes prepared by Prof. Chang will be available on ncueeclass.ncu.edu.tw before the class starts. These will serve as supplementary materials.

   I will be grateful to anyone notifying me of any errors/typos they find in the handouts or problems set or indeed any constructive criticism or comments.

There are NO required textbooks for this course. Some good references are listed below:

1. A. Taflove, S. C. Hagness, *Computational Electrodynamics, the finite-difference time-domain method*, 3rd edition, Artech House, 2005.
2. John B. Schneider, *Understanding the FDTD Method*, 2022.
3. D. L. Lee, *Electromagnetic Principles of Integrated Optics* (Wiley 1986)
4. T. K. Gaylord and M. G. Moharam, Proc. IEEE, **73**, 894 (1985)

Homework Homework problem is due one or two weeks after it is assigned, depending on the difficulties of the problems. No special permission will be given to hand in late. Please upload your MATLAB m-file to the designated folder on ncueeclass. Name your m-file in the format of "Student ID_Your Name_HWx", where x is the homework number (e.g. HW1, HW2, …, etc.). <u>Late homework will not be accepted</u>.

Since all homework is required to write a MATLAB code, no one, including the instructor, is responsible for DEBUGGING your code for you.

Exams One exam, NO quiz!

Grading Policy

Homework	60%
Term Project	25%
Midterm Exam	15%

Learning Outcome

- Theoretical Formulation: As part of this course, students will develop a solid understanding of the theoretical formulation of Finite-Difference-Time-Domain Method.
- FDTD Implementation: Students will demonstrate the implementation of the FDTD method upon completion of this course.

Syllabus

1. Introduction

2. Electromagnetics and FDTD
Review of Maxwell's Equations, Physical Boundary Conditions, Constitutive Relations, Flow of Maxwell's Equations, Finite-Difference Approximation, The First FDTD Algorithm

3. Formulation and Implementation of 1D FDTD (I)
Yee grid scheme, Finite-Difference Approximation of Maxwell's Curl Equations, Governing Equations for 1D FDTD, Derivation of Basic Update Equations, Implementation of Basic Update Equation

4. Formulation and Implementation of 1D FDTD (II)
Numerical Boundary Conditions, Grid Resolution, Courant Stability Condition, Perfect 1D Boundary Condition, Sources, Total-Field/Scattered-Field Soft Source, Fourier Transform, Reflectance and Transmittance, Sequence for Code Development, Convergence, Grid Dispersion, Incorporating Loss

5. Formulation and Implementation of 2D FDTD
From 3D to 2D Maxwell's Equations, Update Equations, Boundary Conditions, FDTD Algorithm for 2D Simulations, Minimizing Simulation Time, 2×Grid Technique, Fitting Structures to a Cartesian Grid

6. The Perfectly Matched Layer
Uniaxial Perfectly Matched Layer (UPML), Conventional PML, PML Parameters, Implementation of UPML in 2D FDTD, Ez Mode, TF/SF Source

7. Grating Diffraction and Plane-Wave spectrum
Wave Vectors, Phase Matching at An Interface, Waves in Periodic Media, Plane Wave Spectrum

Appendix A. Review of Vector Analysis