

Table of Contents

1. **Introduction to Computational Electromagnetics**
 - Role of numerical modeling in RF and microwave engineering
 - Importance of simulation methods in electromagnetic design
 - Application fields: antennas, waveguides, microwave circuits, EMC
 - Benefits and limitations of numerical techniques
2. **Electromagnetic Fundamentals for RF and Microwave Applications**
 - Maxwell's equations
 - Electromagnetic wave propagation
 - Boundary conditions
 - Material properties and constitutive parameters
 - Reflection, transmission, and radiation phenomena
3. **Mathematical Formulation of Electromagnetic Problems**
 - Differential and integral forms of field equations
 - Boundary-value and scattering problems
 - Frequency-domain and time-domain analysis
 - Discretization of electromagnetic quantities
4. **Finite-Difference Time-Domain (FDTD) Method**
 - Principle of the FDTD method
 - Spatial meshing and time stepping
 - Numerical stability and Courant condition
 - Absorbing boundary conditions
 - Applications to RF and microwave structures
5. **Finite Element Method (FEM)**
 - Variational formulation
 - Domain discretization into finite elements
 - Basis functions and matrix assembly
 - Field solution in complex geometries
 - Applications to cavities, resonators, and waveguides
6. **Method of Moments (MoM)**
 - Integral-equation formulation of electromagnetic problems
 - Basis and testing functions
 - Matrix system construction
 - Applications to scattering, antennas, and radiating conductors
7. **Other Numerical Methods in Electromagnetics**
 - Finite-difference frequency-domain techniques
 - Modal methods
 - Hybrid numerical methods
 - High-frequency and asymptotic approaches
8. **Modeling of Materials and Boundary Conditions**
 - Dielectric, conductive, and magnetic materials
 - Anisotropic and dispersive media
 - Perfect and absorbing boundary conditions
 - Loss modeling and non-ideal effects

9. Simulation of RF and Microwave Components

- Transmission lines
- Waveguides
- Resonant cavities
- Microwave filters
- Couplers and passive devices

10. Analysis of Antennas and Radiating Structures

- Wire and printed antennas
- Radiation patterns
- Input impedance and matching
- Radiation simulation and environmental interactions

11. S-Parameters and Device Characterization

- Definition of scattering parameters
- Extraction of S-parameters from simulations
- Physical interpretation in RF and microwave systems
- Performance validation of components

12. Accuracy, Convergence, and Validation

- Numerical errors and approximation sources
- Convergence criteria
- Mesh refinement strategies
- Simulation-to-measurement comparison
- Experimental validation of models

13. Optimization and Simulation-Based Design

- Use of simulation in RF design workflows
- Geometrical and parametric optimization
- Reduction of computational cost
- Integration of simulation tools in engineering design

14. Advanced Applications in RF and Microwave Engineering

- Antenna design and antenna arrays
- Integrated microwave devices
- Electromagnetic compatibility applications
- Radar and wireless communication systems