An Introduction to EM Simulation

Dr. José Ernesto Rayas-Sánchez

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Full-Wave EM Simulation Methods

- Finite Element Method (FEM)
- Finite-Difference Time-Domain (FDTD)
- Finite-Difference Frequency-Domain (FDFD)
- Method of Moments (MoM)
- Transmission Line Matrix (TLM)

References on Fundamental EM Methods

- [FDTD] K. S. Yee, "Numerical solution of initial boundary value problems involving Maxwell's equations in isotropic media", IEEE Trans. on Antennas and Propagation, vol. 14, no. 3, pp. 302-307, 1966.
- [MoM] R. F. Harrington, "Matrix methods for field problems," Proc. IEEE, vol. 55, no. 2, pp. 136-149, Feb. 1967.
- [FEM] P. Silvester, "A general high-order finite-element waveguide analysis program," IEEE Trans. Microwave Theory Tech., vol. 17, no. 4, pp. 204-210, Apr. 1969.
- [TLM] S. Akhtarzad and P.B. Johns, "Transmission-line matrix solution of waveguides with wall losses," Elec. Lett., vol. 9, pp. 335-336, 1973.

Main Full-Wave EM Simulators (2.5-D)

- "2.5-D" = "3-D Planar"
- Sonnet (MoM closed box)
- Keysight Momentum (MoM open box)
- Altair Feko (MoM open box)
- Faustus MEFiSTo* (TLM)
- EM-APLAC* (FDTD)

Main Full-Wave EM Simulators (3-D)

- Keysight EM-Pro (FEM)
- Ansys/Ansoft HFSS (FEM, partial multi-physics)
- Simulia CST (FDTD, partial multi-physics)
- REMCOM (FDTD)
- COMSOL (FEM, fully multi-physics)
- OnScale (FDTD, fully multi-physics)

References on Comparative Studies

- D. G. Swanson, "Simulating EM fields," *IEEE Spectrum*, vol. 28, pp. 34-37, 1991.
- M. S. Mirotznik and D. Prather, "How to choose EM software," *IEEE Spectrum*, vol. 34, pp. 53-58, 1997.
- J. C. Rautio, "Planar electromagnetic analysis," *IEEE Microwave Magazine*, vol. 4, no. 1, pp. 35-41, March 2003.
- W. J. M. Dunn, "Where did EM simulation tools go?: a comparison of how EM tools were used in circuit simulators 25 years ago to today," in *IEEE Microwave Magazine*, vol. 15, no. 1, pp. 65-69, Jan.-Feb. 2014.