Part II

Summary of Modelling Techniques and Available Tools

Slides from T. Hubing, Clemson University

EMC 2010 Workshop

Modeling Software

Fastcap EMA3D Fasthenry NEC

GEMACS SuperNEC FEKO Quickfield

SUPERFISH VISULA FLO/EMC

MaxSIM-F Accufield EMC Workbench

Microwave Explorer MagNet EMIT Fastlap

Maxwell 3D COMPLIANCE EMAP

XFDTD Flux3D MSC EMAS

COMORAN ContecRADIA QUIET

APOGEE EM IE3D MiniNEC HFSS

The HYPE

[redacted]

Comprehensive EM Solutions
field computations involving objects of arbitrary shape

[redacted]

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EMC analysis

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Fluent Releases New[redacted] Software for Rapid Electromagnetic Compatibility and Interference (EMC/EMI) Designs

Posted By:	Fluent <Send Email>
Date:	Wed, 19 Oct 2005, 7:47 a.m.

[redacted] enable Thermal-EM Co-simulation

October 18, 2005, Austin, TX, USA

Fluent Inc., the worldwide leader in computational fluid dynamics (CFD), announces the immediate release of [redacted]0, a three dimensional time-domain full-wave electro package. Along with the industry-leading thermal design software [redacted]wave enables thermal and electromagnetic compatibility and interference (EMC/EMI) co-simulat designers of high-performance electronics systems to dramatically reduce the time required for EMC/EMI design and verification by simulating electronic products in a virtual en

Complete Technology for 3D Electromagnetic Simulation

Choose Complete Technology for your electromagnetic simulation needs. Profit from our broad range of solver technology in an intuitive interface.

Find the solution best fitted for your problem in your market area:

Microwave & RF
Passive microwave & RF component design...

Signal Integrity / EDA
Signal Integrity is an ever increasing concern...

EMC / EMI
Electromagnetic Compatibility and Electromagnetic Interference...

Charged Particle Dynamics
Dynamics of free moving charged particles in electromagnetic fields...

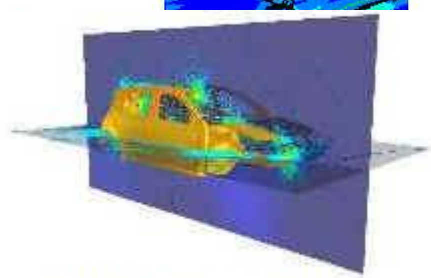
Low Frequency
Structures which are very small in comparison to a wavelength...

FEKO can compute electric and magnetic shielding factors for metallic or dielectric enclosures of arbitrary shape with arbitrary openings cut into them. Shielding effectiveness is typically tested for two scenarios:

available from the manufacturer.)

Software reduces physical testing in automotive EMC.

April 6, 2004 - [redacted] is computational electromagnetic simulation software for analyzing compatibility and interference problems. It includes [redacted], for induced phenomena on cable networks, and [redacted], for low-frequency analysis. Features include capabilities for antenna radiation simulation, modeling for on-board antennas and cable networks, and simulation of 3D radiated fields and induced effects on vehicle cable networks.



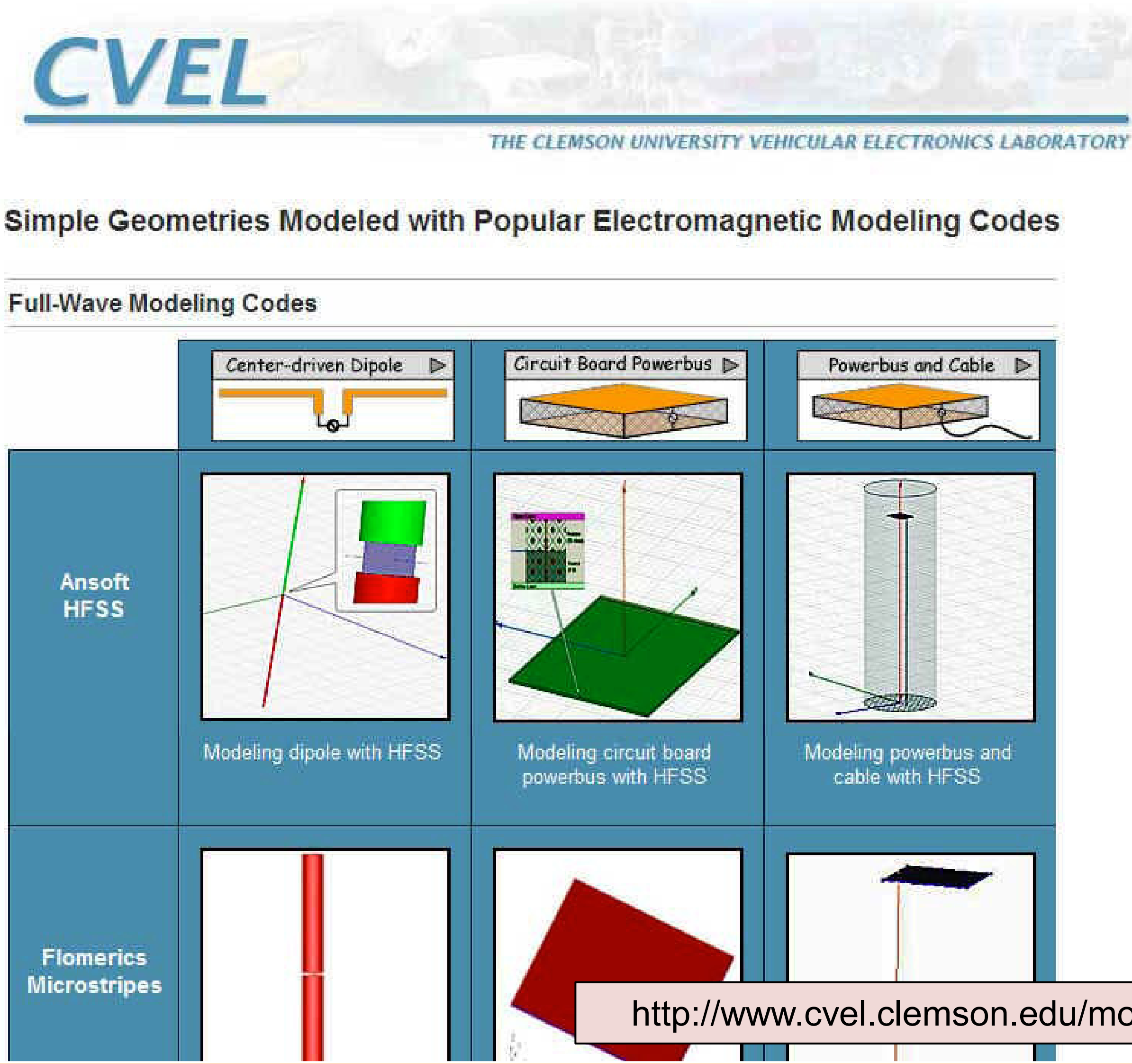
Software reduces physical testing in automotive EMC.

diagrams.

Examples:
- Differential Via Pair
- Multipin Connector
- SI Design from Allegro

EMC/EMI
Electromagnetic radiation from electronic components and radiation into housing can be studied with Microwave Studio. Field monitors are used to determine the EMC spectrum at the standard 3 and 10 meters distances. Linear or circularly polarized plane waves can be used to illuminate a housing to study EMI effects.

Hype vs. Reality



- Even simple geometries are difficult to model using most commercial tools.
- Software attempts to model configurations that it can't model.
- Geometries analyzed are not always the what the user is led to believe.
- Users must understand EM theory.
- Users must be familiar with the limitations of the particular technique.
- Users must be familiar with the peculiarities of the software and its user interface.

http://www.cvel.clemson.edu/modeling/software/

EMC Analysis Software

- Analytical Modeling Software

  specific geometries, closed-form equations
  limited scope, maximum convenience

- Numerical Modeling Software

  solves Maxwell's equations, accurate solutions to well-defined problems
  limited scope, requires expert user

- Design Rule Checkers

  review designs for rule violations that may result in problems
  very limited scope, maximum convenience

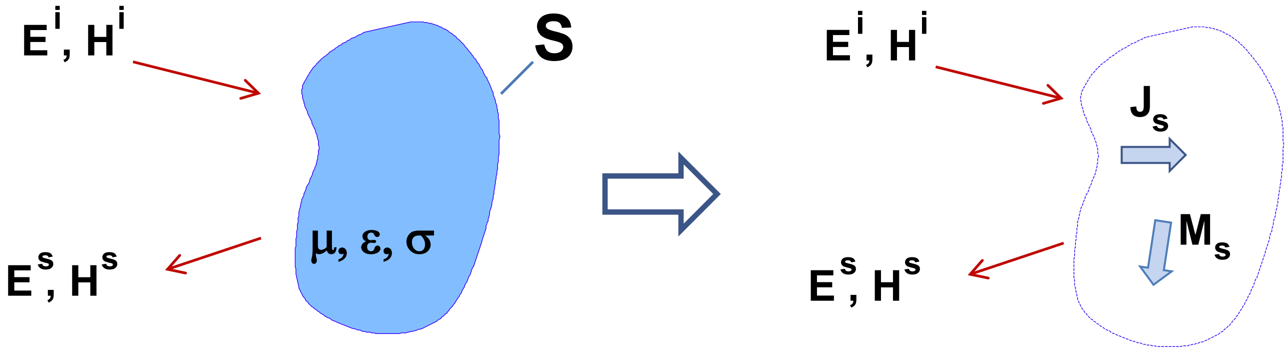
- Expert System / Maximum Emissions Calculators

  review designs for specific problem sources
  identify areas requiring a more careful evaluation
  estimate maximum possible emissions

Numerical Modeling Software

- Static Field Solvers
- 2D Field Solvers
- "2.5 D" Field Solvers
- Transmission Line Solvers
- 3D Field Solvers

Boundary Element Method (BEM)



The Boundary Element Method uses the method of moments to solve a surface integral equation.

- Surfaces of material are gridded
  - (e.g. two-dimensional grid in three-dimensional space)
  - no absorbing boundaries required
  - easier to grid than volume formulations
- Full Matrix Fill / Full Matrix Solution
  - Matrix fill time proportional to N squared
  - Matrix solve time proportional to N cubed
  - Symmetries / special structures can be solved more efficiently.

Boundary Element Method (BEM)

Generally speaking, Boundary Element Methods are very efficient for modeling:

- Thin, electrically long or resonant wires
- Unbounded geometries

They are NOT particularly well suited for modeling:

- Complex source geometries
- Dielectrics
- Thin metal surfaces
- Tightly coupled, electrically small conductors

Boundary Element Method (BEM)

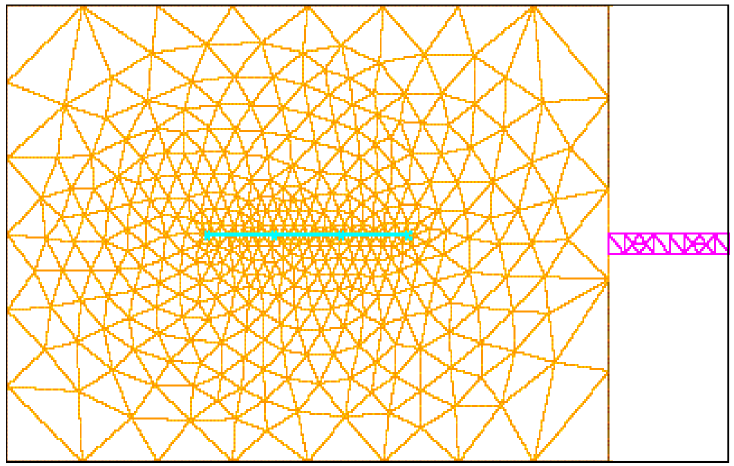
Commercial BEM/MoM Modeling Software:

- Agilent Momentum
- Ansoft Q3D Extractor
- CONCEPT II
- EZNEC
- FEKO
- GEMACS
- IES Magneto / Electro / Coulomb
- IES Singula
- MiniNEC
- NEC-Win Pro
- SAIC EMTOOLS
- SimLab PCBMod
- Sonnet Suites
- SuperNEC
- WIPL-D
- Mentor - Zeland IE3D

Free BEM/MoM Modeling Software:

- NEC2
- Expert MiniNEC Classic
- FEKO Lite
- IBM EMSIM

Finite Element Method (FEM)



- Entire Volume is Meshed
  - absorbing boundaries required for open problems
  - 3D FEM absorbing boundaries must be kept far from objects being modeled
- Sparse Matrix Fill / Sparse Matrix Solution
  - Grids to not need to be uniform.
  - Fine mesh can be used in areas with large field gradients
  - Symmetries / special structures can be modeled more efficiently.

Finite Element Method (FEM)

Generally speaking, Finite Element Methods are very efficient for modeling:

Complex source geometries

Dielectrics

Thin metal surfaces

Tightly coupled, electrically small conductors

They are NOT particularly well suited for modeling:

Thin, electrically long or resonant wires

Unbounded geometries

Finite Element Method (FEM)

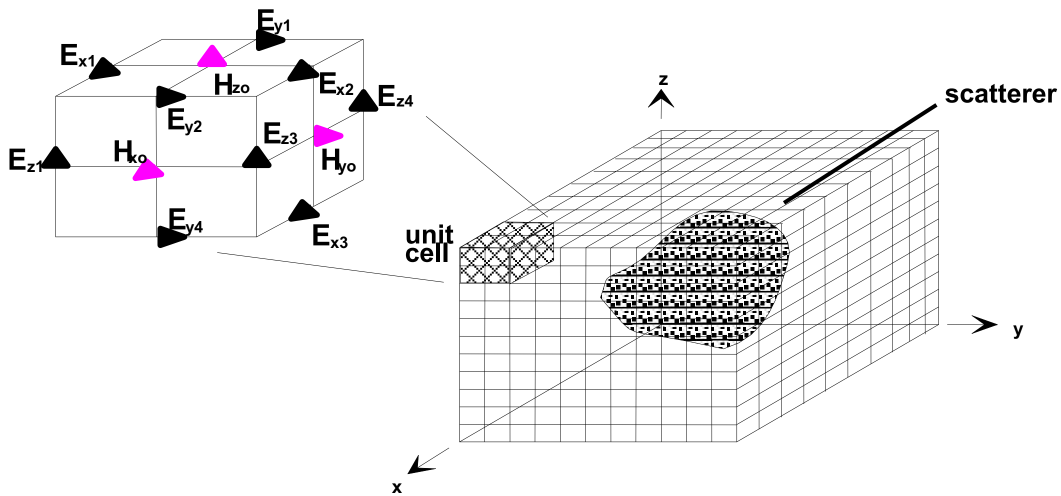
Commercial FEM Modeling Software:

- Ansoft HFSS
- Ansoft Maxwell 2D / Maxwell 3D
- Comsol Multiphysics
- MagSoft Flux 2D / Flux3D
- PAM-CEM
- Vector Fields Opera-2d

Free FEM Modeling Software:

- FEMM
- Ansoft Maxwell SV
- EMAP
- RillFEM
- Students' QuickField

Finite Difference Time Domain (FDTD)



- Entire Volume is Meshed
  - absorbing boundaries required for open problems
  - 3D FDTD absorbing boundaries work very well
  - cell size (mesh density) must be uniform
- No Matrix, Time-Stepped Solution
  - Solution time proportional to number of cells.
  - cell size determined by uniformity of field and length of time steps.

Finite Difference Time Domain (FDTD)

Generally speaking, FDTD Methods are very efficient for modeling:

Complex source geometries

Dielectrics

Thin metal surfaces

Tightly coupled, electrically small conductors

They are NOT particularly well suited for modeling:

Thin, electrically long or resonant wires

Unbounded geometries

Finite Difference Time Domain (FDTD)

Commercial FDTD Modeling Software:

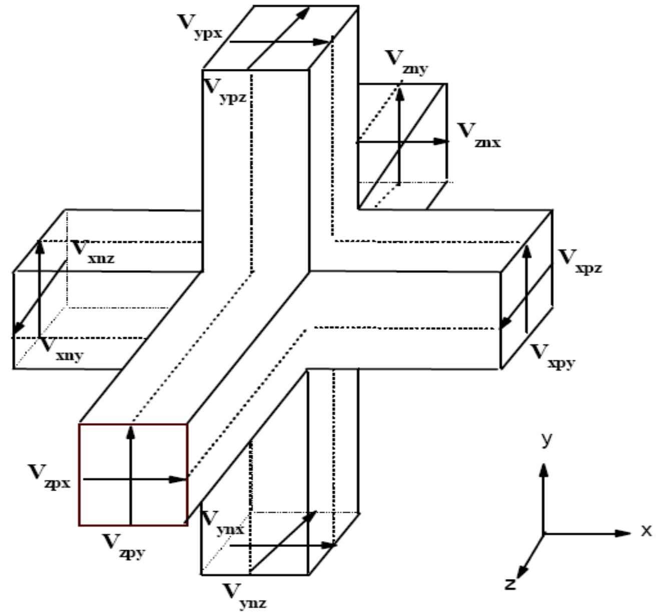
- ApsimFDTD
- CST – Transient Solver
- EMA3D
- EMPLab
- EMCUBE
- EZ-FDTD
- EMPIRE
- SIM 3D Max
- Remcom XFDTD
- SEMCAD X
- Speed2000
- Vector Fields CONCERTO
- Zeland Fidelity
- 2COMU: GEMS

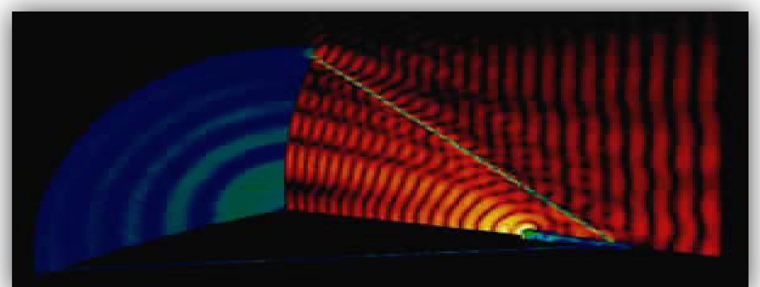
Free FDTD Modeling Software:

- Arpeggio
- Cray LC
- MEEP
- ToyPlaneFDTD / ToyFDTD

Transmission Line Matrix Method (TLM)

- Field propagation is modeled with a 3D circuit grid through all of space.
- Advantages and disadvantages very similar to FDTD codes.
- Requires more memory than FDTD.
- More convenient termination of grid at material boundaries than FDTD.
- More intuitive for some people, less intuitive for others.

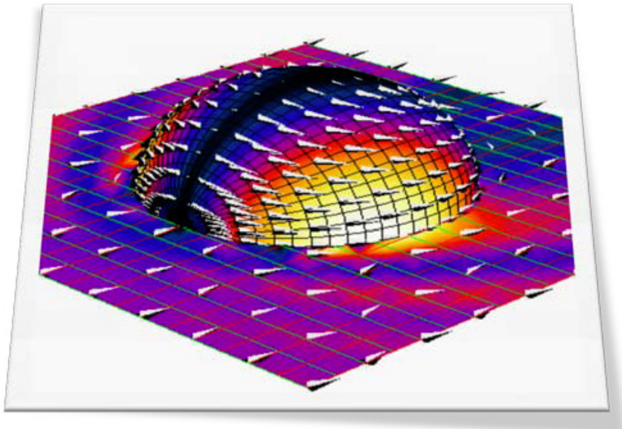




Commercial Tools:

CST Microstripes
MEFiSTo-3D

Generalized Multipole Technique (GMT)

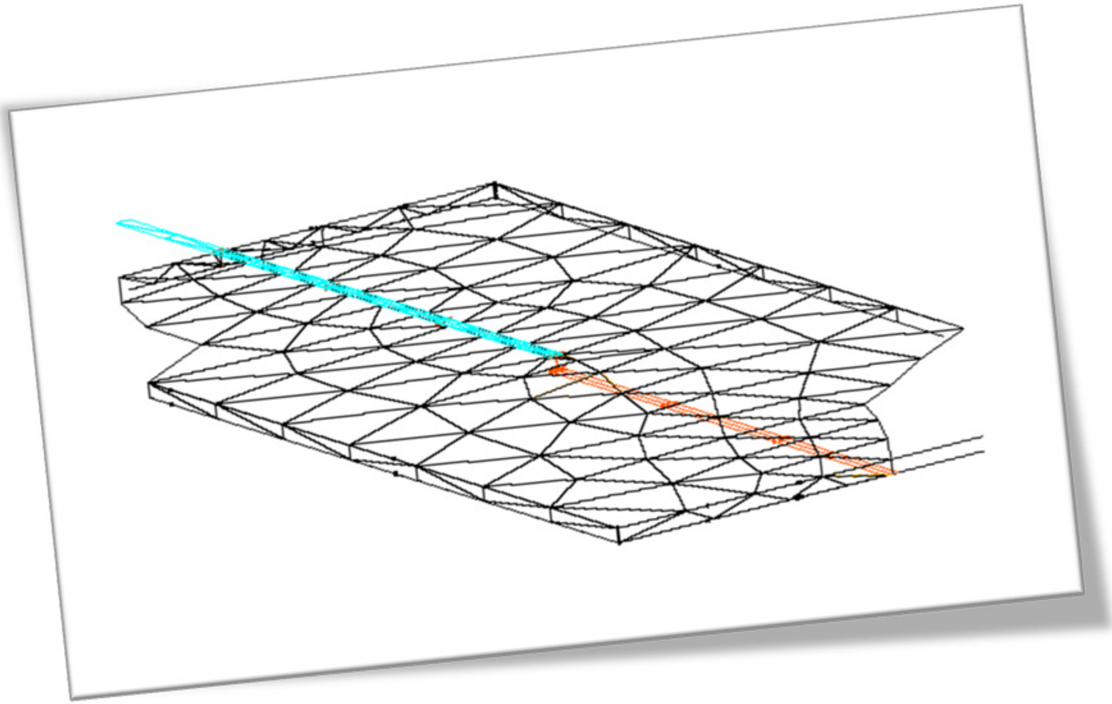


Commercial Tools:

MMP
Max-1

- A Moment Method Technique
  - basis and weighting functions are fields from multipole sources
  - placement of multipole sources on object geometry is critical
  - efficient, but can be less intuitive to use.
- Full Matrix Fill / Full Matrix Solution
  - Matrix fill time proportional to N squared
  - Matrix solve time proportional to N cubed
  - Symmetries / special structures can be solved more efficiently.

Finite Element Time Domain (FETD)

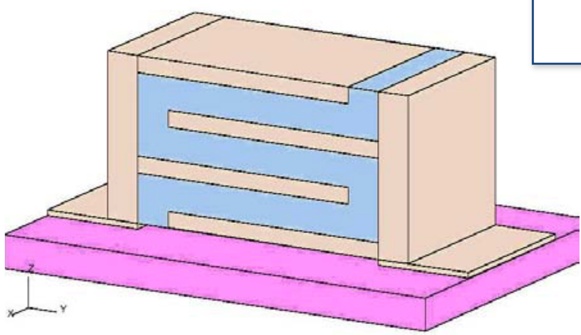


Commercial Tools:

Efield 4.0
EMFLEX

- A Finite Element Technique Implement in the Time Domain
  - Employs an unstructured grid (like FEM in frequency domain)
  - Unconditionally stable for implicit time integration
  - Sparse matrix must be solved at each time step.

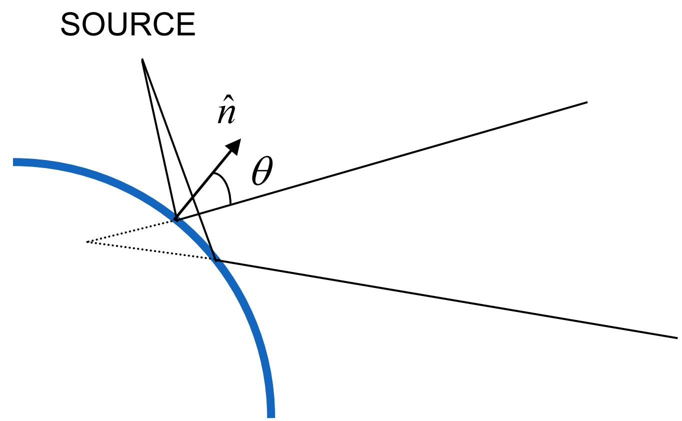
Partial Element Equivalent Circuit Method (PEEC)



Commercial Tool:	Ansoft TPA (parameter extraction)
Free Tool:	IBM LCGEN (static fields)

- A circuit approach to EM modeling
  - Grids metal surfaces like a BEM technique
  - Models all EM interactions with mutual inductances and mutual capacitances
  - Creates a large circuit that is solved with a modified SPICE algorithm
  - Can be solved in the time or frequency domain

Geometric Theory of Diffraction (GTD)
Uniform Theory of Diffraction (UTD)
Physical Optics (PO)



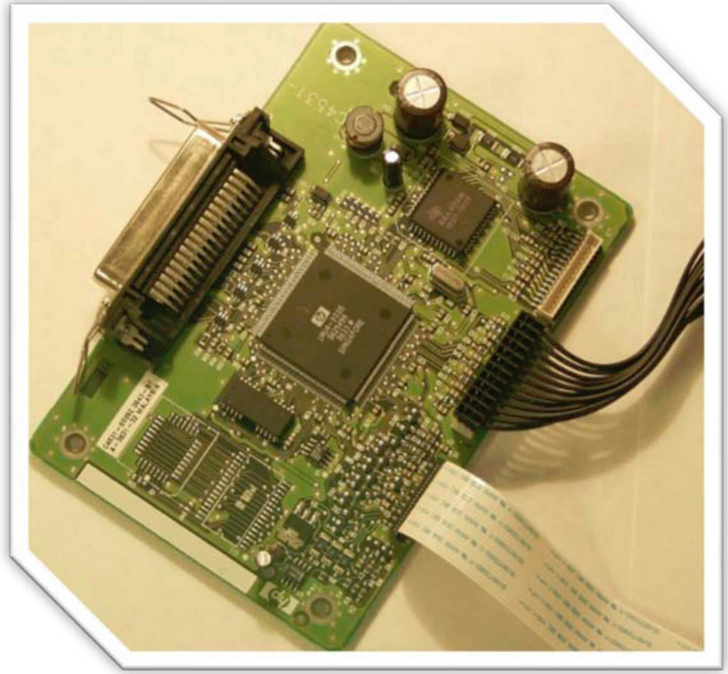
- High-Frequency Ray Tracing Techniques
  - No matrix to solve
  - Rays emanate from source
  - Bend around corners based on diffraction calculations
  - Wavelengths must be small relative to objects being modeled.

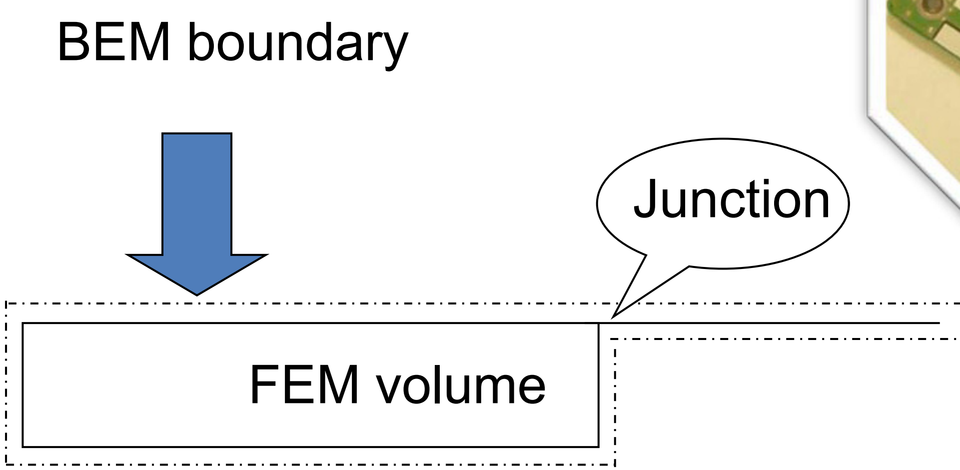
Geometric Theory of Diffraction (GTD)
Uniform Theory of Diffraction (UTD)
Physical Optics (PO)

Commercial Software:

- ALDAS
- CONCEPT II
- GEMACS
- FEKO
- Remcom XGtd
- SAIC EMTOOLS
- SuperNEC

Hybrid Methods





Circuit board is modeled with FEM. The off-board wires are modeled by BEM.

Low-Cost CEM Tools

Free Software:

- FEMM
- Ansoft Maxwell SV
- EMAP
- Students' QuickField
- Antenna Model
- LC
- MEEP
- OpenFMM
- pdnMesh
- Radia
- ToyFDTD
- Scatlab

$2k - $10k:

- EZ-EMC
- EZNEC Pro
- GEMACS
- Tricomp-Estat
- Trace Analyzer

CEM Tools (more than $10k)

- AMDS
- All IES codes (Ampere …)
- Analyst
- ApsimFDTD-SPICE
- AXIEM
- CableMod/PCBMod
- Compliance
- Comsol Multiphysics
- CRIPTE
- CST Microwave Studio
- EMA3D
- EMC Studio
- EMDS
- Maxwell
- MFlex
- emGine Environment
- EMPIRE Xccel
- Fidelity
- FEKO
- GEMS
- HFSS
- HFWorks
- IE3D
- JCMSuite
- OptEM Cable Designer
- OptEM Inspector
- Magnet
- Microwave Office
- Momentum
- PAM-CEM
- Q3D Extractor
- SEMCAD X
- Sonnet
- WIPL-D Pro
- Xenos
- XFDTD
- XGtd

Key Point

Computer models often yield incorrect results because:

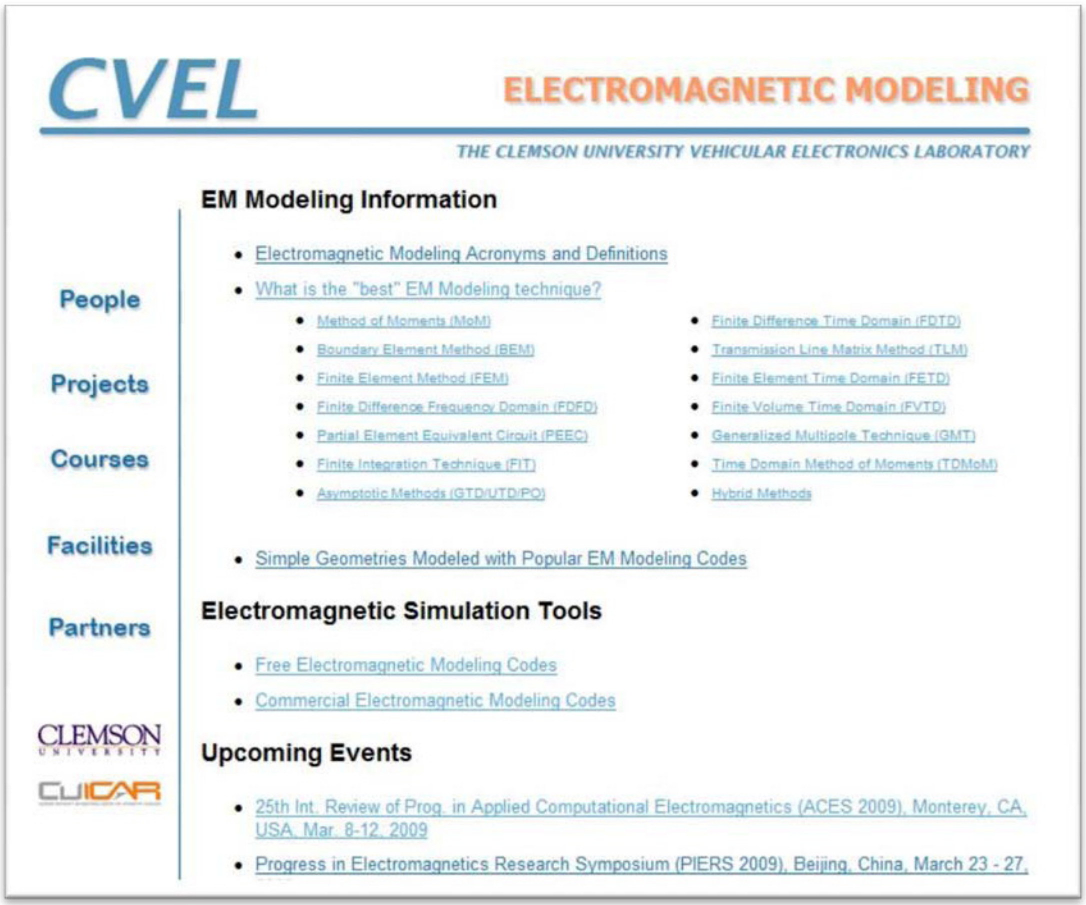
- Software was not capable of analyzing the input configuration
- Software defaults were inappropriate for the problem
- The input was not exactly what the user thought
- Results were misinterpreted by the user

Summary

- Numerical EM modeling tools require the user to be familiar with EM theory, the limitations of the techniques being applied, and the limitations of the particular software implementation.
- Numerical EM modeling tools should only be trusted when the solutions can be confirmed by other methods.
- Numerical EM modeling tools are NOT particularly useful for the design and troubleshooting of digital electronics products.

For More Information:

http://www.cvel.clemson.edu/modeling



- List of “free” EM modeling codes.
- List of commercial EM modeling codes.
- Info on EM modeling techniques.
- Info on EM modeling software.