∆∇EMA3D

Premier 3D Electromagnetic Simulation

EMA3D is a powerful 3D numerical solution of Maxwell's curl equations based on the time-domain finite-difference method in rectangular coordinates. The codes have application to nearly any EM coupling, radiating or interaction problem. Typical applications include:

- EMI/EMC interaction
- High Intensity Radiated Fields (HIRF)
- Lightning interaction
- Antenna analysis
- Shielding calculations
- Coupling to aircraft
- Printed circuit board EMC
- High power microwave
- Biomedical electromagnetics
- Nuclear Electromagnetic Pulse
- Microwave/millimeter wave
- Multi port network analysis
- Monolithic integrated circuit (MMIC) design and analysis
- Wideband or pulsed CW RCS

Basic capabilities and features of EMA3D version 3

- Perfect electric conductors
- Lossless or lossy dielectric media (ε, μ, σ and σ_m can be specified).
- Thin wires (resistive loads and resistance per unit length)
- Thin gaps
- Frequency dependent surface and transfer impedances of lossy surfaces (e.g., carbon fiber materials)
- Time varying air conductivity
  - Caused by air breakdown (corona)
  - Electron, positive and negative ion fluid model
  - Two choices: with or without allowable space charge (with or without convective derivative)
  - Useful for gamma ray interaction with air; air breakdown
- Boundary Conditions
  - Perfect conductor
  - Mur, Fang-Mei
  - Low frequency magnetostatic
  - PML
- As many as 6 symmetry planes allowed.
- Sources: voltage, current, current density, magnetic current density, electric fields, magnetic fields, plane waves
- Plane wave sources for objects
  - In free space
  - Over lossy earth
  - On or within lossy earth
- Frequency domain post processing
  - Fourier transforms
  - Transfer functions
  - *S* parameters
  - Input impedances
  - Radar Cross Section
  - Filtered results
  - Input, reflected, and available powers
- Far field extrapolation
  - In free space
  - Over perfectly conducting ground plane
  - For radiated emissions, antenna patterns, scattering cross sections
- Sub grid feature in two steps
- Supported platforms: SGI, SUN, HP, IBM RS/6000, DEC Alpha, Cray Unicos, Windows NT, some Parallel Architectures

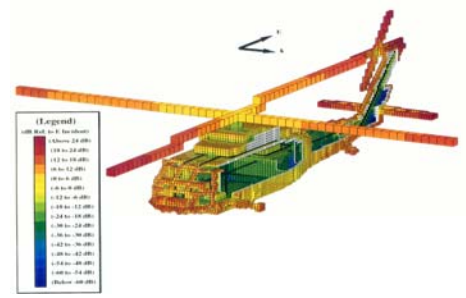
Advanced features of EMA3D version 3

- Independently variable mesh in *x*, *y*, or *z*-directions
- 2D solutions for any two of the Cartesian coordinate axes
- Thin gaps can contain any material, including non-linear air.
- Self consistent surface and transfer impedances for thin sheets, such as ITO (indium tin oxide) coatings or carbon fiber composites
- Improved thin wire algorithm
  - Availability of a variety of *RLC* passive terminations
  - Imbedded in any kind of medium
  - User specified inductance per unit length
  - Functions with symmetry planes
- Isotropic electric and magnetic materials with frequency dependence. That is, ε, μ, σ, σ_m can all be represented with a set of any number of user defined 1st and 2nd order rational functions
- Anisotropic electric and magnetic materials with user defined frequency independent tensor elements:

$$[\varepsilon]=\begin{pmatrix}\varepsilon_{xx} & \varepsilon_{xy} & \varepsilon_{xz}\\ \varepsilon_{yx} & \varepsilon_{yy} & \varepsilon_{yz}\\ \varepsilon_{zx} & \varepsilon_{zy} & \varepsilon_{zz}\end{pmatrix} \qquad [\mu]=\begin{pmatrix}\mu_{xx} & \mu_{xy} & \mu_{xz}\\ \mu_{yx} & \mu_{yy} & \mu_{yz}\\ \mu_{zx} & \mu_{zy} & \mu_{zz}\end{pmatrix}$$

$$[\sigma]=\begin{pmatrix}\sigma_{xx} & \sigma_{xy} & \sigma_{xz}\\ \sigma_{yx} & \sigma_{yy} & \sigma_{yz}\\ \sigma_{zx} & \sigma_{zy} & \sigma_{zz}\end{pmatrix} \qquad [\sigma_m]=\begin{pmatrix}\sigma_{m,xx} & \sigma_{m,xy} & \sigma_{m,xz}\\ \sigma_{m,yx} & \sigma_{m,yy} & \sigma_{m,yz}\\ \sigma_{m,zx} & \sigma_{m,zy} & \sigma_{m,zz}\end{pmatrix}$$

- Additional boundary conditions
  - Low frequency electrostatic
  - Perfect magnetic conductor
  - Periodic in *x*, *y*, *z*, or in any combination
  - Different boundary conditions can be applied to each boundary surface.

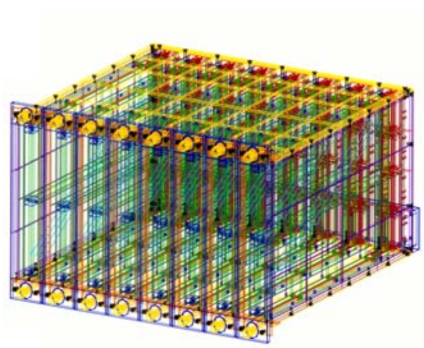


- Inclusion of any number of implicitly meshed isotropic linear or non-linear media. These "background media" are not meshed in the GUI, but are implicitly meshed in the solver, greatly reducing size of the meshed problem.
- In addition to the probes already available which can be used to import results into CADfix, other powerful probes are now available which produce 3D results and geometry visualizations directly from the solver itself, as well as column formatted ASCII data files.
  - Screen Probe: allows the user to write certain electromagnetic quantities to the computer screen (or to a log file) such as the *x*, *y*, and *z* components of the electric and magnetic fields, thin wire currents, and thin gap voltages.
  - Time and Frequency Domain Probe: similar to the Screen Probe, with the addition of frequency domain results, such as the fast Fourier transform and transfer functions. The frequency domain results are computed "on the fly" and written to column formatted data files at the end of the simulation. A Prony algorithm option is also provided.
  - Bulk Current Probe: allows the user to output the total current on surfaces or volumes containing several nodes.
  - Picture Probe: allows the user to create time domain or frequency domain (FFT, transfer functions) pictures of the electromagnetic behavior of the structure being modeled.
  - Slice Probe: allows the user to create time domain or frequency domain (FFT, transfer functions) pictures of the electromagnetic behavior on slices through the finite difference problem space.
  - Structure Probe: allows the user to create Postscript files of the structure being modeled. The user has the ability to specify what material or structures are desired and the corresponding color.
  - Fine Structure Probe: creates a text file displaying the material or geometry at each field component location. This is useful if one wants a detailed understanding of the structure being modeled.

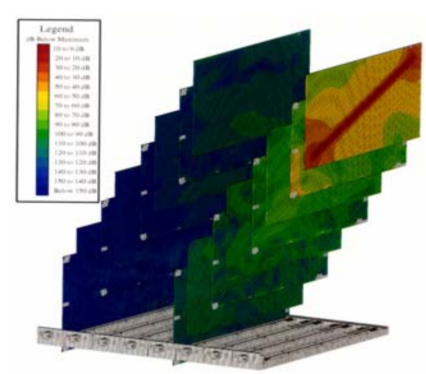
EMA3D Graphical User Interface

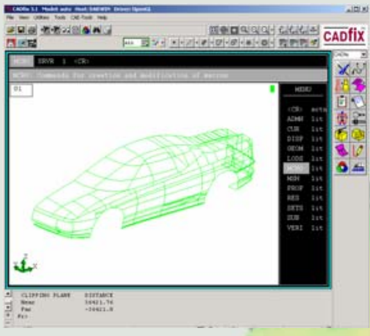
Called EMA-CAD it consists of CADfix produced by FEGs, Ltd. of Cambridge, UK, augmented by an EMA developed tool set. It provides world class pre-and post-processing capabilities with the following capabilities:

- Model building from CAD, by keyboard/mouse, primitives
- Extensive CAD file repair and processing facilities.
- Extensive CAD-like model building capability
- Primitive structures available for model building
- Creation and export of IGES and other CAD files
- Automatic mesh generation
- Open framework architecture
- Setup of EMA3D solver with interactive GUI tools
- Individual user customization via Tcl/Tk
- Light source shading
- X, GL, VGL and Open GL drivers
- Rotation, zoom, and position by mouse
- Visualization of sections or parts of models and meshes
- Visualization
  - Geometry, mesh, nodes, material properties, results
  - Time and frequency domain plots
  - False color surface plots
  - Deformed contour surface plots
  - Animations in time or frequency domains. Animations can also be rotated and zoomed with the mouse while in process.
  - Streamlines

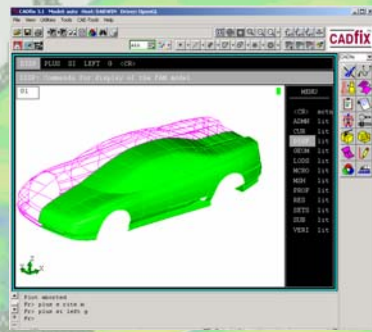


The user can either build models directly in CADfix or can import the geometry from CAD files formats such as IGES and STEP, and from several other CAD systems. The electronic enclosure shown here was imported from IGES files. CADfix simplified the geometry to produce an analysis model that was used for intra-system EMC simulations. The coupling to other internal PCBs from a clock pulse source on another PCB was evaluated. The coupling is visualized at the right.

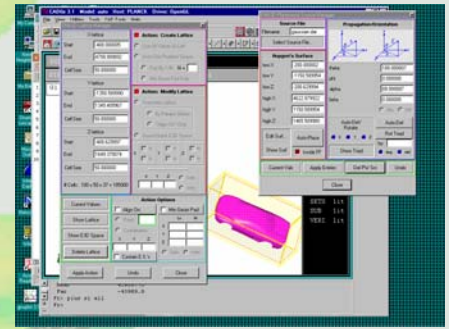




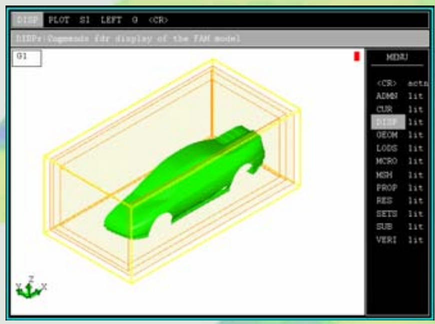
Simulation begins with creating geometry, which can be done by the GUI modeling capabilities, or by import of CAD files as shown here.



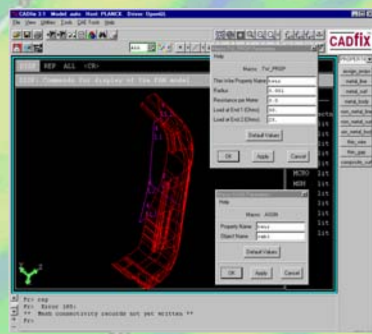
The CAD file only had the left half; the right half was easily created by the GUI using a reflect command. There are 500 surfaces in this model.



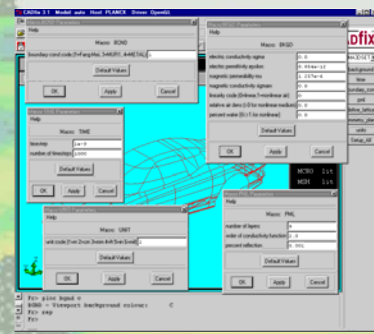
GUI tools such as the lattice manager and plane wave manager make it easy for the user to set up the problem.



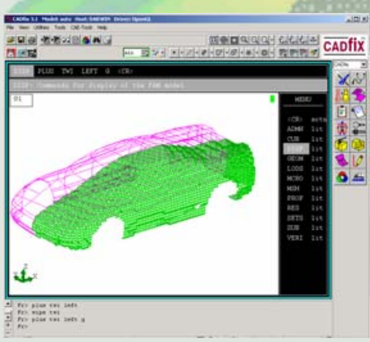
This shows 4 surfaces from outside in: lattice boundary, problem space boundary, far field integration surface, and the Huygens' surface.



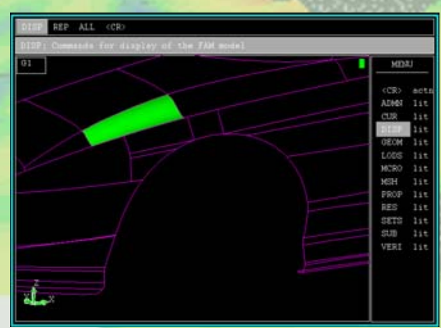
A wire harness was added to the model by the GUI. Material properties, such as the thin wire property, are created and assigned to objects.



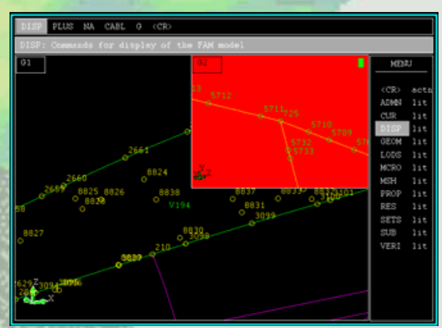
Other GUI tools set up problem parameters. Note that background color can be changed.



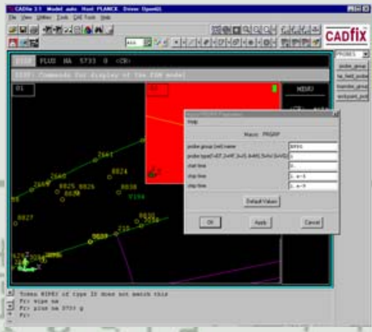
Meshing is done by a single mouse click. The mesh of any part can be individually visualized.



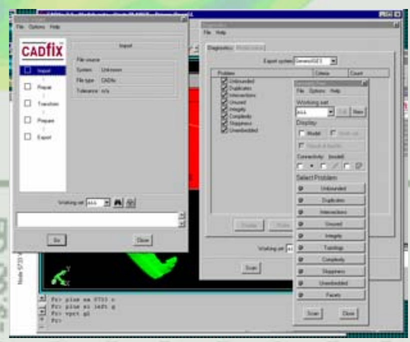
Any part can be selected and visualized. Material properties of any part can be assigned and visualized.



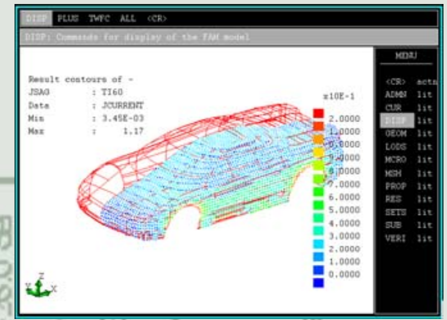
Any number of view ports can be created to show various problem aspects, such as node numbers on a single surface, and on the wire harness.



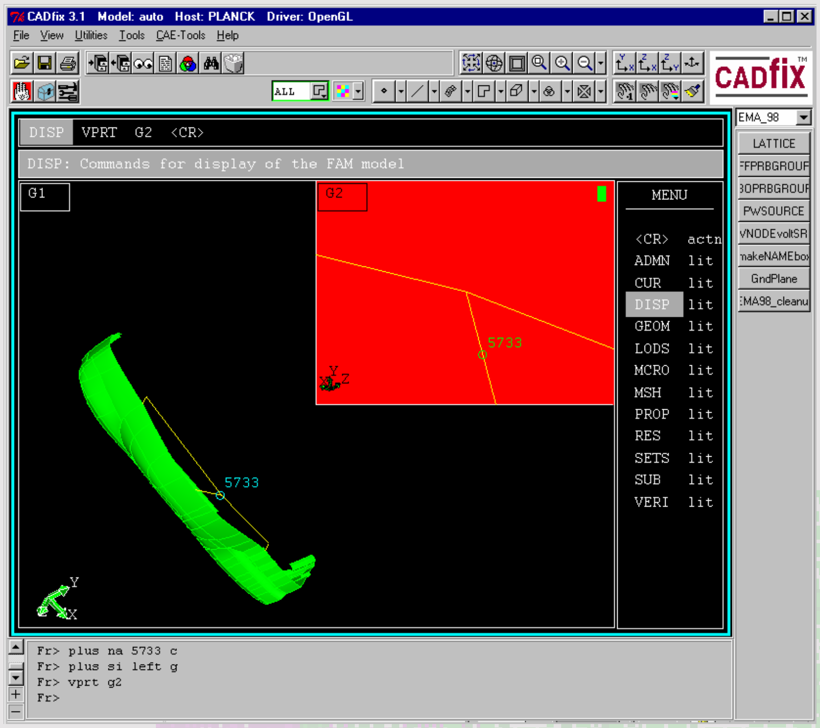
Results are stored in probe groups, consisting of sets of nodes, created by the GUI.

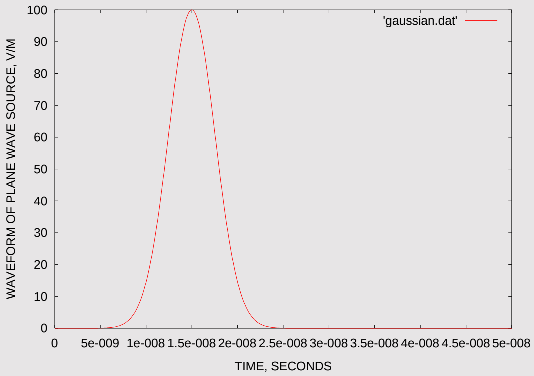


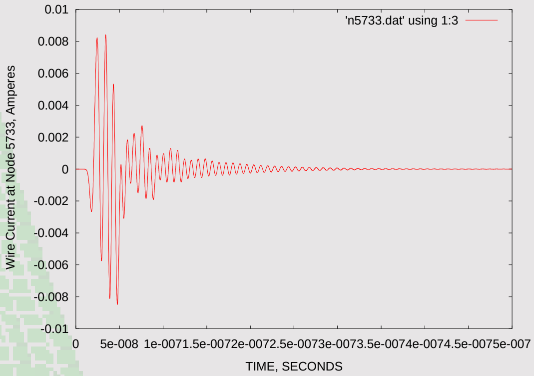
CADfix has considerable capability to import, scan, and automatically repair geometry, as shown by these GUI tools.

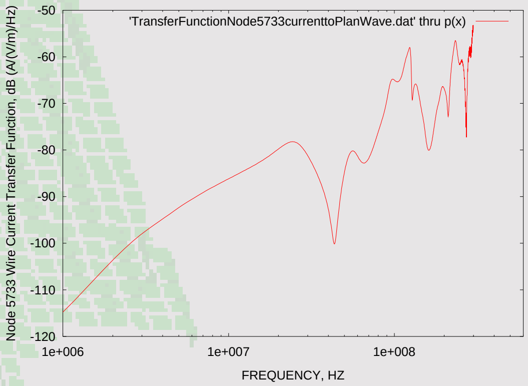


Time or frequency domain results can be overlaid on the geometry or the mesh for visualization. Animations are easily made from such plots.









An Example of Obtaining Frequency Domain Information from Time Domain Results

It is desired to determine the transfer function between the induced wire current at node 5733 of a wire harness and a plane wave incident from the top polarized parallel to the car’s axis of travel. The indicated time domain Gaussian pulse is created as the incident waveform. The wire current computed at node 5733 is also shown. The EMA3D post processing utilities are used to easily compute the transfer function, plotted in dB A/(v/m)/Hz. Broadband spectral information is obtained with one time domain simulation.

EMA

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