ANSYS®

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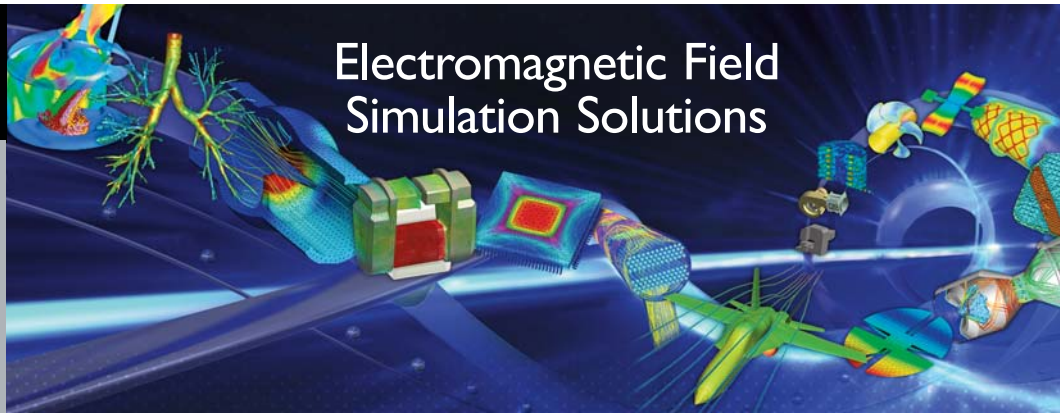


Maxwell Features

Low-frequency electromagnetic field simulation and analysis using FEM for 3-D/2-D structures

- Transient-nonlinear analysis with:
  - Motion-rotation, translational, non-cylindrical rotation
  - External circuit coupling
  - Permanent magnet demagnetization analysis
  - Core loss computation
  - Lamination modeling for 3-D
- AC electromagnetic: analysis of devices influenced by skin/proximity effects, eddy/displacement currents
- Magnetostatic: nonlinear analysis with automated equivalent circuit model generation
- Electric field: transient, electrostatic/current flow analysis with automated equivalent circuit model generation
- Automatic, adaptive mesh technology
- Fault-tolerant meshing algorithms
- Mesh-generation feedback
  - GUI performs validation and integrity checks
  - Software identifies artifacts within the imported geometry
- Mesh-based model resolution
- Display of data/visualization of results
  - Field visualization and animations (shaded, contour and vector plots)
  - Mesh visualization (full, partial)
  - Current, induced voltage, flux linkage
  - Power loss, stored energy
  - Core loss, eddy, excess, hysteresis loss (including the minor loop effects)
  - Impedance, inductance, capacitance
  - Force, torque
  - Custom reports of user-defined solution data

Electromagnetic Field Simulation for the Design of High-Performance Electrical and Electromechanical Products

The depth and breadth of ANSYS electromagnetic field solutions was enhanced by the acquisition of Ansoft and incorporating its industry-leading electromagnetic field solvers into the ANSYS software portfolio. These new products cover the full spectrum of electromagnetic analysis and design. ANSYS electromagnetic solutions enable users to leverage best-in-class software technology to predict the behavior of high-performance electrical and electromechanical devices, eliminate prototype iterations and deliver products to market faster. ANSYS electromagnetic solutions address the analysis needs of three distinct application areas:

Electromechanical: electric motors and generators, transformers, bus bars, relays, solenoids, power electronics, MEMS and magnet design

High-speed electronic components: on-chip embedded passives, IC packages and PCB interconnects

High-frequency devices: antennas, RF/microwave components, EMI/EMC and biomedical devices

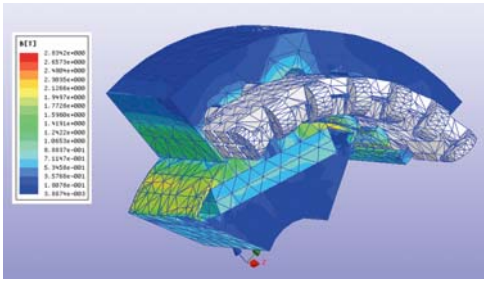
ANSYS electromagnetic solutions allow the user to gain an understanding of:

- Device performance characteristics under applied loads/excitations and boundary conditions
- Visualization of the electromagnetic field in and around a device
- Joule heating effects and resultant temperatures
- Force distribution and resulting deformation
- Key design parameters: torque, force, resistance, inductance, capacitance, impedance, S-parameters and radiated fields/emissions

Electromagnetic Products

ANSYS electromagnetic solutions are a comprehensive offering for electromagnetic analysis.

Maxwell® is a software package for low-frequency electromagnetic field simulation. Maxwell can be used to design 3-D/2-D structures, such as motors, actuators, transformers and other electromagnetic and electromechanical devices. Maxwell technology is based on the finite element



Magnetic flux distribution of a permanent magnet motor assembly; simulation performed with Maxwell technology

Maxwell Applications

Electromechanical
- Motors and generators
- Linear or rotational actuators
- Relays
- Magnetic recording heads

Electromagnetic
- Coils
- Permanent magnets
- Sensors

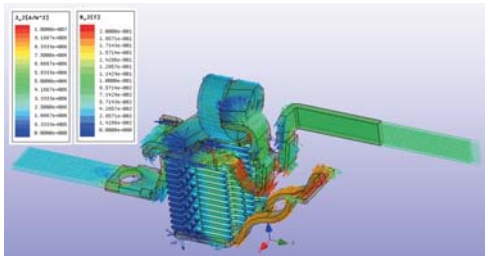
Power electronic and power distribution
- Transformers
- Converters
- Cables
- Bus bars
- IGBTs and similar devices

EM behavior
- Insulation studies
- Electrostatic discharge
- Electromagnetic shielding
- Nondestructive analysis
- EMI/EMC
- Semiconductor
- Biomedical

HFSS Features

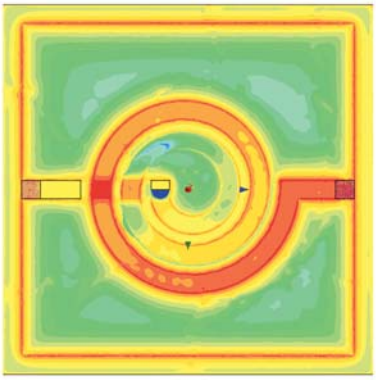
- 3-D full-wave EM field simulation
- Tangential vector finite elements
- Automatic adaptive mesh generation and refinement
- S-,Y-, Z-parameter extraction via transfinite elements
- Adaptive Lanczos Pade Sweep (ALPS)
- Model healing, automatic feature recognition, mesh resolution control and fault-tolerant meshing for CAD import
- Low-, medium- and higher-order basis functions
- Direct and iterative matrix solvers (64-bit capability)
- Eigenmode matrix solver (64-bit capability)
- Generalized multi-mode port definitions including lossy and Floquet ports
- Auto-assign for terminal-driven ports
- Multiple incident field sources including small current loop, dipoles and arbitrary plane waves

analysis method and uses the Ansoft-pioneered automatic adaptive meshing techniques. This robust meshing algorithm automatically creates and refines the finite element mesh as the solution converges, streamlining the solution process and making the software very easy to use.

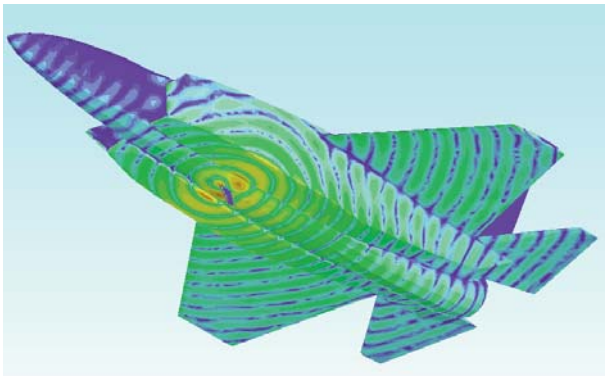


Magnetic flux density on the core and current density on the conduction path in a high power breaker; simulation performed with Maxwell software

Maxwell software can solve static, frequency-domain and time-varying electromagnetic and electric fields. In addition, the software can be dynamically linked with Simplorer® software to create a powerful, system-level, electromagnetic-based design flow. This flow enables users to combine complex circuits with accurate component models generated from the Maxwell application to design and analyze complete systems. Additionally, Maxwell software has links to ANSYS® Mechanical™, and ANSYS® FLUENT® products, allowing engineers to perform complex multiphysics studies.

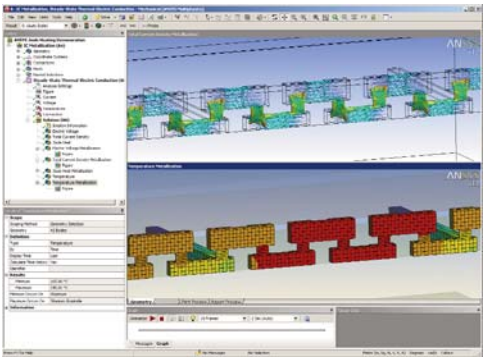


Electric fields around on-chip spiral inductor



Surface currents from a UHF blade antenna mounted on an aircraft; simulation performed with HFSS software

HFSS software is the industry-standard simulation tool for 3-D full-wave electromagnetic field simulation. HFSS technology provides E- and H-fields, currents, S-parameters and near and far radiated field results. Intrinsic to the success of HFSS software as an engineering design tool is its automated solution process, whereby users are only required to specify geometry, material properties and the desired output. From that point, HFSS software will automatically generate an appropriate, efficient and accurate mesh for solving the problem using the proven finite element method. With HFSS technology the physics defines the mesh, not the other way around. HFSS software has links to the ANSYS Mechanical and ANSYS® DesignXplorer™ tools, allowing users to perform comprehensive multiphysics analyses and optimization studies. Engineers rely on HFSS technology to design high-speed components, including on-chip embedded passives, IC packages, PCB interconnects and high-frequency components such as antennas, RF/microwave components and biomedical devices.



Coupled thermoelectric simulation of an IC metallization structure performed in the ANSYS Workbench environment; simulation performed with ANSYS Multiphysics technology

ANSYS® Emag™ software, an add-on module for ANSYS Mechanical software, addresses analysis needs for applications that require low-frequency electromagnetics strongly coupled to the mechanics, such as microelectromechanical devices (MEMS), induction heating and charged particle tracing.

ANSYS® Multiphysics™ software contains all the features of the ANSYS Emag product plus a high-frequency full-wave solver and many other physics capabilities within the ANSYS® Workbench™ environment. ANSYS Multiphysics software is ideal for the evaluation of coupled physics prevalent in electromechanical devices such as electromagnetic-thermal and electromagnetic–thermal–structural coupling.

Applications

Electromechanical Design

Maxwell software is used for electromagnetic field analysis including magnetic transient with motion, AC electromagnetic, magnetostatic, transient electric field and electrostatic/current flow analysis. Maxwell provides accurate solutions for field parameters such as force, torque, capacitance, inductance, resistance and impedance along with the ability to visualize electromagnetic fields. Applications include motors and alternators, sensors, rotating and linear actuators, power generators, transformers, transmission lines, bus bars, magnetic recording heads and other electromechanical devices.

A key feature in Maxwell software is the ability to generate high-fidelity, equivalent circuit models for use in Simplorer multi-domain system simulation software. This creates a powerful electromagnetic-based design flow that enables users to combine complex circuits with accurate, physics-based component models to design complete high-performance electromechanical and power electronic systems. This powerful multi-domain design approach allows engineers to accurately model, simulate and validate component, circuit and system-level performance.

High-Speed/High-Frequency Electronic Design

Engineers and designers rely on the accuracy, capacity and performance of HFSS software to design on-chip embedded passives, IC packages, PCB interconnects, antennas, RF/microwave components and biomedical devices. With HFSS software, engineers extract S-, Y-, Z-parameters, visualize 3-D electromagnetic fields and emissions and generate Full-Wave SPICE™ compatible models to evaluate signal quality.

Engineers use HFSS software for radio frequency (RF) and microwave applications such as the design of high-frequency components and circuits found in the transmitter and receiver portions of communication systems, radar systems, satellites and cellular telephones. Additionally, HFSS software is used to evaluate electromagnetic interference between multiple connectors, transmission lines and vias on printed circuit boards (PCBs) and high-speed components used in computer servers and storage devices, multimedia PCs, entertainment systems and telecom systems.

A key feature within HFSS software is the ability to generate high-fidelity equivalent circuit models for use in Nexxim® high-performance circuit simulation software from Ansoft for time- and frequency-domain applications.

Solution Data

- S-parameters (single-ended, differential, de-embedded, renormalized)
- Far-field calculation (2-D, 3-D, gain, angular beam width)
- Port mode and impedance calculation by 2-D-eigenmode solver fields
- SAR calculation
- Mode conversion
- Material losses, radiation losses

Equivalent Circuit Models

- Nexxim, HSPICE®, Cadence® Virtuoso® Spectre® Circuit Simulator and MATLAB® compatible

Data Display/Result Visualization

- S-, Y-, Z-parameter matrix
- Plots
  - 2-D/3-D Cartesian/polar plots, Smith charts and data tables
  - Overlay measurement data
  - Copy vector graphics to clipboard
  - Display trace characteristics, markers, delta markers and X markers
  - Copy and paste of plot definition or data from one report to another
  - Library of report templates: create templates from reports, vice versa
- Port surface characteristic impedance
- Differential S-parameter, TDR display
- 3-D static and animated field plots on any surface
  - Current, electric field, magnetic field
  - Radiation pattern, emissions test
- Vector display, magnitude display
- Ranged functions – extract calculations such as maximum, minimum and average from a plot or dataset

HFSS Applications

RF and Microwave

Antennas
- Linear wire, slot, horn, patch
- Phased array including array-to-radome interaction
- Personal wireless devices
- RFIDs

Passive components
- Antenna feed structures
- Filters, circulators, connectors, waveguide transitions
- Embedded passives (i.e., spiral inductors, MIM and MOM capacitors)
- MEMS

RF PCBs
- Wireless devices, guidance systems, mobile base stations

Biomedical
- MRI devices, SAR studies

High Speed

ICs
- Embedded passives
- Spiral inductors
- Transformers
- MOM and MIM capacitors
- Critical interconnects
- Vias
- Clocktrees
- Transitions
- MMICs, RFICs, MEMS

IC packages
- SiP, PoP, CSP, BGA, LTCC, MCM, LTCC, MCM
- Lead-type (QFP, QFN, DiP, SO)
- PGA, BGA (wire-bonded, flip chip)

Printed circuit boards
- Vias, lands
- Transmission lines
- Gridded power/ground planes
- Rigid/build-up/flexible PCBs

Connectors, cables, sockets

MEMS and Charged-Particle Tracing

ANSYS Emag, an add-on program to ANSYS Mechanical software, is ideal for designing MEMs and charged-particle tracing applications. ANSYS Emag is integrated into the ANSYS Workbench environment and simulates low-frequency electric currents and electric fields in conductive and capacitive systems, as well as magnetic fields resulting from currents or permanent magnets. The program can also simulate charged-particle tracing in both electrostatic and magnetostatic fields.

Multiphysics

Multiphysics solutions from ANSYS provide high-fidelity engineering analysis tools that enable the accurate simulation of complex coupled-physics behavior. ANSYS multiphysics solutions combine industry-leading solver technology for all physics disciplines — structural mechanics, heat transfer, fluid flow and electromagnetics — with the open and adaptive ANSYS Workbench environment, flexible coupled-physics simulation methods and parallel scalability. Together these cutting-edge technologies form the foundation for comprehensive multiphysics simulation capable of solving industry's most complex engineering challenges. ANSYS multiphysics solutions deliver two proven solution techniques to solve multiphysics problems — the direct coupled-field elements and the ANSYS Multi-field solver. These approaches provide flexible simulation methods to solve a broad range of both direct and sequentially coupled multiphysics problems such as Joule heating, piezoelectricity, electrostatic actuation, induction heating and electro-thermal-structural interaction prevalent in electromechanical devices. Together, the two solution techniques provide the appropriate solution technology to solve an extremely broad range of industry applications. Devices such as thermoelectric coolers, accelerometers, piezoelectric sensors, MEMs and many other devices are all readily analyzed with ANSYS multiphysics solutions.

The ANSYS Advantage

With the unequalled depth and unparalleled breadth of our engineering simulation solutions, companies are transforming their leading edge design concepts into innovative products and processes that work. Today, 97 of the top 100 industrial companies on the "*FORTUNE* Global 500" invest in engineering simulation as a key strategy to win in a globally competitive environment. They choose ANSYS as their simulation partner, deploying the world's most comprehensive multiphysics solutions to solve their complex engineering challenges. The engineered scalability of our solutions delivers the flexibility customers need, within an architecture that is adaptable to the processes and design systems of their choice. No wonder the world's most successful companies turn to ANSYS — with a track record of almost 40 years as the industry leader — for the best in engineering simulation.

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