



Product Features

Elements

- ▶ 2-D planar and axi-symmetric – quadrangle and triangle shapes
- ▶ 3-D full – brick, pyramid, prism and tetrahedral element shapes
- ▶ Symmetry planes, periodic boundary conditions

Magnetostatic and Quasi-Static Eddy Currents

- ▶ Static, harmonic and transient fields, forces, losses, energies, power
- ▶ Coupling to circuit, heat transfer, structural dynamics, conduction
- ▶ Linear and nonlinear materials, permanent magnets
- ▶ 2-D and 3-D magnetic vector potential
- ▶ 3-D edge flux formulation
- ▶ Scalar potential (static)

Electrostatics

- ▶ H and adaptive p-elements
- ▶ Hybrid FEA/BEA domain – integral equation, Trefftz method
- ▶ Transducers for coupled structural dynamics – MEMS

Steady-State Current Conduction

- ▶ Joule heating and coupled heat transfer
- ▶ Currents can be used for magnetostatic excitation

Low-Frequency Electric

- ▶ Quasistatic electric
- ▶ Time-harmonic analysis for linear materials
- ▶ Time-transient analysis for linear materials
- ▶ Joule heating and coupled heat transfer
- ▶ Currents can be used for magnetostatic excitation

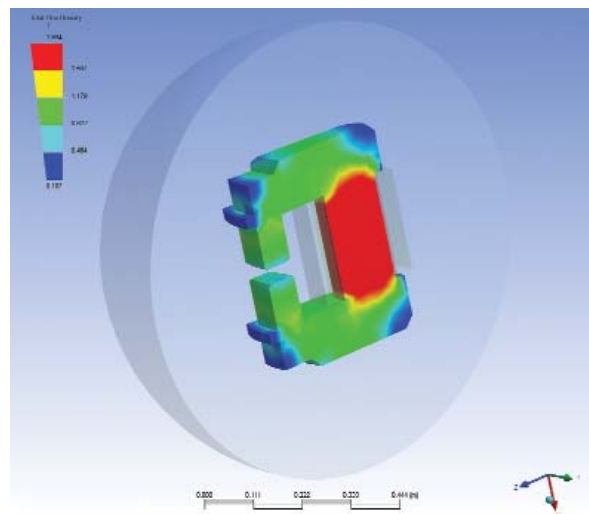
Ion Optics

- ▶ Trace charged particles in electromagnetic fields

Electromagnetics Simulations Are Critical to Electrical and Electronic Product Designs Across Many Industries

The ANSYS Electromagnetics solution addresses the analysis needs of two distinct electromagnetics sectors or application areas:

- ▶ Low-frequency: electric motors, relays, solenoids and magnet design, MEMS
- ▶ High-frequency: PCB, RF/microwave components, antenna, scattering/FSS, EMI/EMC, biomedical effects



The ANSYS Electromagnetics solution allows 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 device
- ▶ Low-frequency: electric motors, relays, solenoids and magnet design, MEMS
- ▶ Electromagnetic-joule heating effect and resultant temperatures
- ▶ Extraction of key design parameters, such as motor torque or S-parameters

ANSYS, Inc. offers electromagnetics virtual prototyping and design tools that can replace many aspects of electromagnetics physical testing. This reduces product time-to-market, decreases development costs and allows the user to enhance and optimize the performance of products with minimal physical prototype costs. In most cases, professionals who design and simulate an electrical/electronic product will definitely see value in the ANSYS Electromagnetics solution.

Product Features

Circuits

- ▶ Resistors, inductors, capacitors, diodes
- ▶ Independent and controlled current and voltage generators
- ▶ Transducers – for electro-mechanical coupling – MEMS
- ▶ Static, harmonic, pre-stressed harmonic and transient analyses

Low-Frequency Materials, Boundary Conditions, Excitations and Effects, Output

- ▶ Soft and hard magnetic, linear and non-linear permeable materials
- ▶ Current and voltage excitations – independent and circuit coupled
- ▶ Stranded and massive/solid conductors, coils, bars, arcs
- ▶ Meshless coils, bars, arcs current source, Biot-Savart integration
- ▶ Capacitive, inductive, conductive, proximity effects, eddy currents
- ▶ Velocity effects – motion formulation, magnetic Reynolds number
- ▶ Displacement currents
- ▶ Lossy dielectrics
- ▶ Symmetry planes, cyclic symmetry, periodic boundary condition
- ▶ Electromagnetic contact
- ▶ Electromagnetic field, heat, force, torque, power, loss, flux
- ▶ Inductance, capacitance, conductance matrix – lumped parasitic extraction
- ▶ Coupling to heat transfer, structural dynamics, circuit and fluid analyses

Low-Frequency Applications

- ▶ Electric motors, generators, transformers, actuators, sensors
- ▶ Magnetic levitation, bearings, stirring, electric guns, solenoids, toroids, permanent magnets
- ▶ Eddy current braking systems, induction heating and hardening
- ▶ Printed circuit boards, power electronics, inductive ignition systems
- ▶ Ion optics, cathode ray tubes, photo multipliers, electron discharge
- ▶ Particle accelerators and detectors, plasma devices, trajectory tracing
- ▶ Geophysical and medical non-destructive testing instruments
- ▶ MEMS
- ▶ Lossy capacitors and dielectrics
- ▶ High-voltage insulators
- ▶ Biomedical imaging

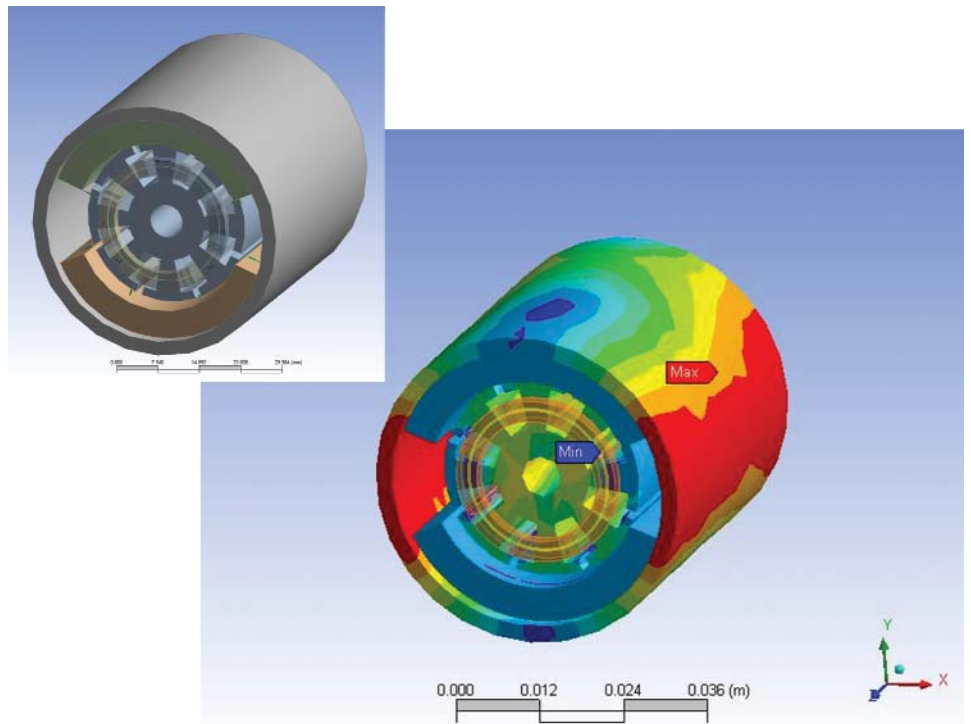
Electromagnetics Products

The ANSYS Electromagnetics solution is provided by two products:

- ▶ ANSYS® Emag™
- ▶ ANSYS® Multiphysics™

ANSYS Emag software addresses the analysis needs of the low-frequency electromagnetics market (electric motors, relays, solenoids, toroids, induction heating, accelerators, geophysical/medical instruments and magnet design). ANSYS Emag can be used as an independent package or in combination with other ANSYS® software suite products, such as ANSYS® Mechanical™, to enable even more comprehensive simulation of real-world phenomena.

ANSYS Multiphysics software addresses the analysis needs of both low- and high-frequency electromagnetic markets. This technology contains all the features of the ANSYS Emag product plus high-frequency full-wave solver and many other physics capabilities. Therefore, it provides the most complete electromagnetics solution available on the market.



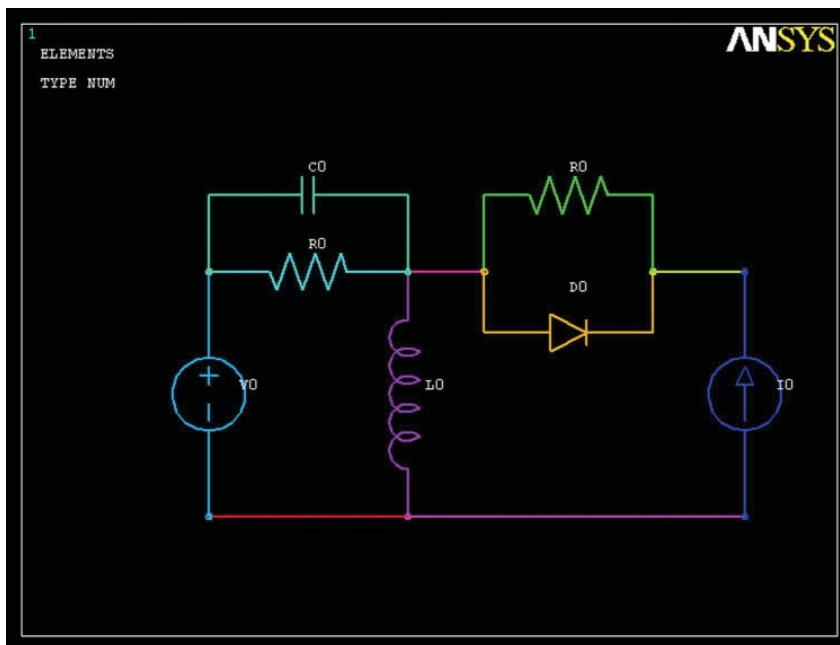
Electromagnetic analysis of permanent magnet motor (inset: solid model) showing total magnetic flux density

Low-Frequency Electromagnetics

ANSYS low-frequency electromagnetics analysis products are used for steady-state, time-transient, time-harmonic electric and magnetic field studies. Users can simulate forces, torques, energies, losses, fields, eddy/conduction currents and coil fluxes as well as the inductance, capacitance and conductance system matrices of inductors, capacitors and resistors. Exciting currents, voltages, permanent magnetic loads, fluxes and charges may be known before simulation or computed by coupled field/circuit analysis. The technology also can simulate charged-particle tracing in both electric and magnetic steady-state fields.

Applications include rotating machines (motors and alternators), sensors, actuators, power generators, transformers, transmission lines, induction heating, magnetic levitation/stirring/bearing, non-destructive testing instruments and micro-electro-mechanical systems (MEMS). The ANSYS Emag product provides a comprehensive range of analysis features to address the diverse needs of electrical engineers, from motor design to ion optics.

A circuit builder enables the user to apply time-harmonic, time-transient (including large amplitude time-transient), voltage and current loads directly to a finite element model via a graphically generated circuit schematic. Users can arbitrarily arrange the resistors, capacitors, diodes, inductors, wires, transformers, voltage and current sources, as well as other components. The circuit coupling to the finite element domain allows for simulating circuit-fed devices in which nonlinear (saturation) effects must be considered.



An example of a circuit builder model

Product Features

High-Frequency Full Wave

The ANSYS Multiphysics solution provides a high-frequency (or full-wave) electromagnetic simulation capability applicable to resonant, propagating, radiation and scattering phenomena in the frequency domain.

Geometry and Meshing Tool

- ▶ ANSYS prep7 solid model
- ▶ CAD connections with IGES, SAT, Pro/ENGINEER®, UG, PARA
- ▶ Automatic and manual meshing
- ▶ Adaptive meshing

Zero/1st-Order Tangential Vector Element

- ▶ 3-D tetrahedral, hexahedral, prism, and pyramid element
- ▶ 2-D quadrilateral and triangle element

Material Model

- ▶ Isotropic permittivity, permeability, electric resistivity, electric loss tangent, magnetic loss tangent
- ▶ Anisotropic permittivity, permeability, electric current conductivity, magnetic current conductivity, nonlinear B-H material

Boundary Conditions and Excitation Sources

- ▶ Perfect electric conductor (PEC)
- ▶ Perfect magnetic conductor (PMC)
- ▶ Standard impedance boundary conditions (SIBC)
- ▶ Perfectly matched layers (PML)
- ▶ Periodic boundary condition (PBC)
- ▶ Perfect magnetic conductor (PMC)
- ▶ Symmetric planes (only for post-processing)
- ▶ Port
- ▶ Lumped gap source
- ▶ Plane wave
- ▶ Surface, line electric field (voltage source)
- ▶ Impressed current density
- ▶ RLC lumped circuit

Solver Technology and Solution Control

- ▶ SPARSE direct solver
- ▶ Iterative solver
- ▶ Optional Multiphysics Frequency Sweep VT product module for fast frequency sweep
- ▶ Adaptive S-parameter solution

Product Features

Post-Processor and Output

- ▶ Electromagnetic fields vector and contour patterns
- ▶ Pointing vector
- ▶ Quality factor (Q-factor)
- ▶ S-parameter extractor (single-ended, de-embedding and renormalization)
- ▶ Network parameter conversion
- ▶ Touchstone format output file
- ▶ Smith chart
- ▶ Input, reflected, dissipated and transmitted power
- ▶ Voltage, current and characteristic impedance
- ▶ Conducting current density distribution
- ▶ Near and far electromagnetic fields
- ▶ Antenna/phased array antenna parameters (pattern, gain, etc.)
- ▶ Radar cross section (RCS)
- ▶ Specific absorption rate (SAR)
- ▶ Joule heat
- ▶ TDR/TDT display
- ▶ Full-wave RLCG SPICE sub-circuit
- ▶ Coupled high-frequency electromagnetic-thermal analysis

Applications

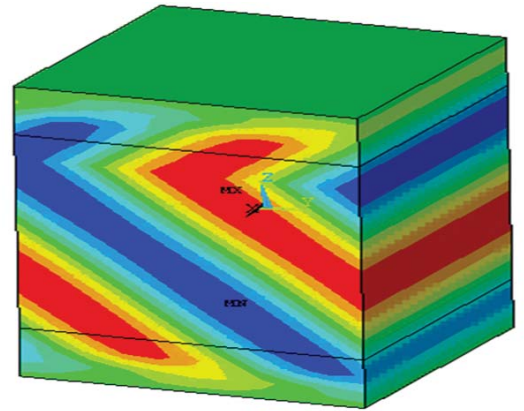
- ▶ High-speed electronic circuits
- ▶ PCB interconnects
- ▶ RF/microwave components
- ▶ Antenna
- ▶ Object identification
- ▶ Frequency selective surface
- ▶ EMI/EMC
- ▶ RF/microwave heating and biomedical effects

Coupled Electromagnetic-Thermal Applications

- ▶ Heat treating
- ▶ Induction hardening
- ▶ Plastic welding
- ▶ Food processing
- ▶ Ceramic sintering
- ▶ Process drying
- ▶ Film curing and drying

High-Frequency Electromagnetics

The ANSYS Multiphysics solution provides a high-frequency (or full-wave) electromagnetic simulation capability applicable to resonant, propagating, radiation and scattering phenomena in the frequency domain. Applications include the design of RF/microwave passive components as well as circuits, antenna design and object identification.



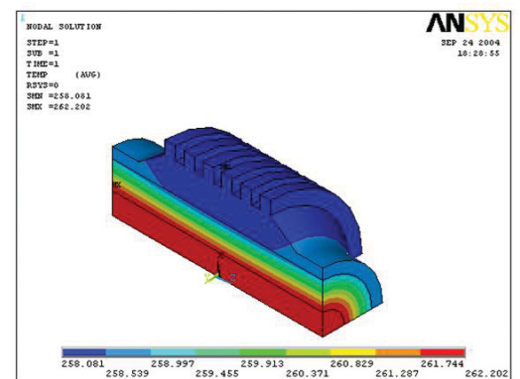
Electromagnetic wave scattering off of a periodic structure at 10 GHz

Automated post-processing calculations provide electric and magnetic field intensity, quality factor, scattering matrix parameters, voltage, current, characteristic impedance, radar cross section, near- and far-electromagnetic fields beyond the modeled domain, and antenna patterns.

The optional Multiphysics Frequency Sweep VT product module uses advanced Variational Technology (VT) for efficient calculation of frequency-dependent parameters.

Coupled Electromagnetic-Thermal Analysis

In many electromagnetic systems, electromagnetic energy is lost in the form of heat in lossy dielectrics and resistive conductor materials. This is often referred to as Joule loss or Joule heating. The ANSYS Electromagnetics solution can simulate Joule heating effects by coupled electromagnetic and heat transfer physics. Applications include RF attenuators, resistive heaters, RF heaters and microwave ovens.



RF heating of a coaxial load