

Product Features

Geometry

- ▶ 2-D planar
- ▶ 2-D axi-symmetric
- ▶ 3-D full & symmetry planes

Analysis Classes

Electrostatics

- ▶ H and adaptive p-elements
- ▶ Hybrid FEA/BEA domain

Magnetostatics

- ▶ Scalar Potential
- ▶ Magnetic Vector Potential
- ▶ 3-D Edge Flux Formulation
- ▶ 2-D Planar and axi-symmetric geometry

Ion Optics

- ▶ Trace charged particles in static fields

Steady-State Current Conduction

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

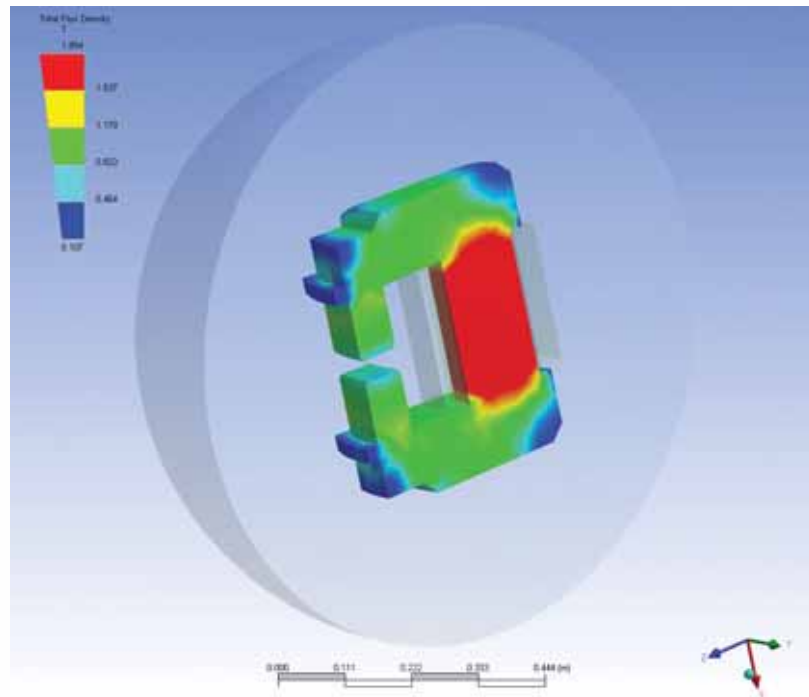
Low-Frequency Magnetic

- ▶ Quasistatic magnetic
- ▶ Time-harmonic analysis for linear materials
- ▶ Time-transient analysis for linear and nonlinear materials
- ▶ Magnetic Vector Potential
- ▶ 3-D Edge Flux Formulation

Electromagnetic simulations are critical to electrical and electronic product designs across many industries.

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

- ▶ Low-frequency: electric motors, relays, solenoids and magnet design
- ▶ High-frequency: radio frequency and microwave device design, RF MEMS



Analysis of an electromagnet showing total magnetic flux density.

The ANSYS Electromagnetics solution allows the user to gain an understanding of:

- ▶ Device performance characteristics under applied loads and boundary conditions
- ▶ Visualization of electromagnetic field in and around device
- ▶ Electromagnetic-joule heating effect and resultant temperatures
- ▶ Extraction of key design parameters such as motor torque, or S parameters

The ANSYS Electromagnetics solution is a virtual prototyping tool that can replace many aspects of electromagnetics physical testing. This reduces product time to market, reduces development costs and allows the user to enhance and optimize the performance of products with minimal physical prototype costs.

Generally speaking, if you engineer, manufacture or test anything that could be described as an electrical/electronic product, then you will definitely see value in the ANSYS Electromagnetics solution!

Product Features

High-Frequency

- ▶ Tangential vector elements
- ▶ Brick, pyramid, prism and tetrahedral element shapes
- ▶ Cavity modal analysis
- ▶ Harmonic analysis: wave propagation, radiation and scattering

Low-Frequency Materials, Boundary Conditions & Effects

- ▶ Permeable and non-permeable domains
- ▶ Current and voltage excitation
- ▶ Stranded coils and Massive conductors
- ▶ Biot-Savart coils
- ▶ Capacitive & inductive effects
- ▶ Velocity effects
- ▶ Eddy currents
- ▶ Displacement currents
- ▶ Lossy dielectrics
- ▶ Inductance matrix calculation
- ▶ Capacitance matrix extraction
- ▶ Conductance matrix extraction
- ▶ Cyclic symmetry
- ▶ Electromagnetic contact
- ▶ Electromagnetic torque & force
- ▶ Force coupling to structural

Applications

- ▶ Electric motors, alternators
- ▶ Linear motion systems
- ▶ Permanent magnet systems
- ▶ Eddy current braking systems
- ▶ Inductive ignition systems
- ▶ Ion optics
- ▶ Particle detection
- ▶ Non-destructive testing
- ▶ Induction hardening
- ▶ Lossy capacitors
- ▶ High voltage insulators
- ▶ Biomedical imaging
- ▶ Electric impedance tomography

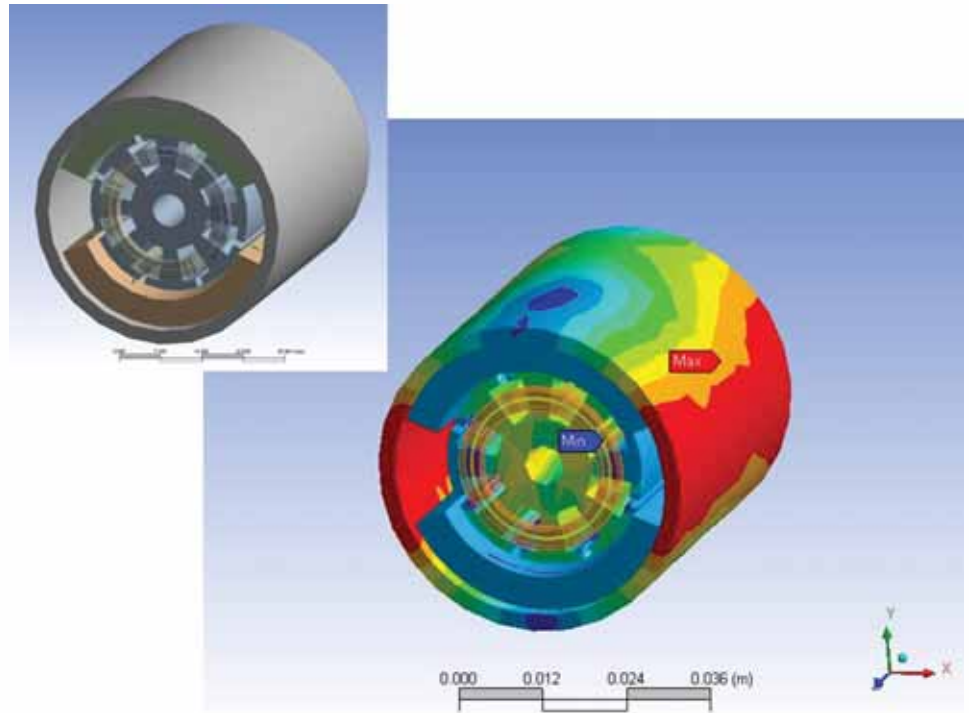
Electromagnetic Products

The ANSYS Electromagnetics solution is provided by two products:

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

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

The ANSYS Multiphysics product addresses the analysis needs of both low- and high-frequency electromagnetic markets. ANSYS Multiphysics contains all of the features of the ANSYS Emag product, plus many other physics capabilities, and thus, provides the most complete electromagnetics solution available on the market today.



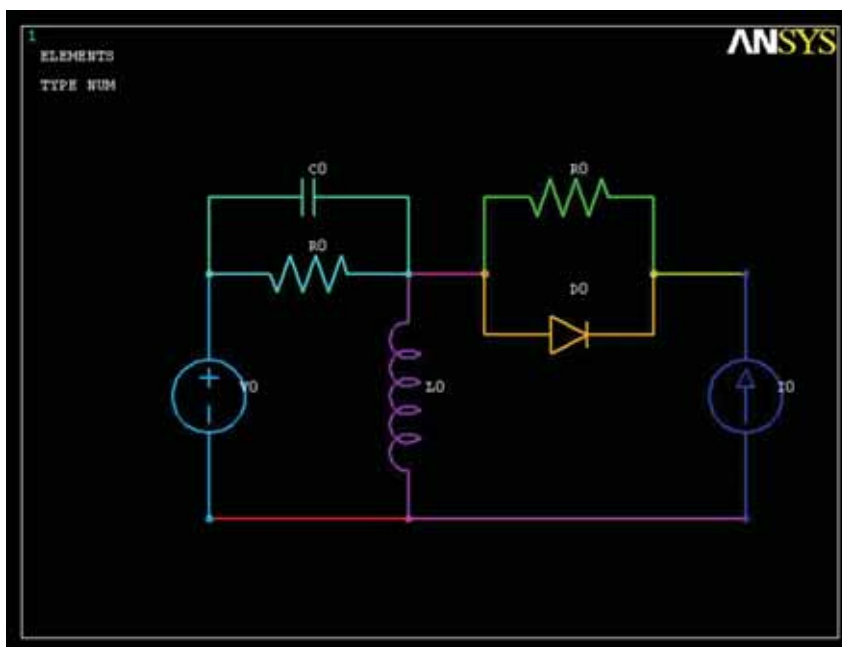
Electromagnetic analysis of permanent magnet motor (inset: solid model), showing total magnetic flux density.

Low-Frequency Electromagnetics

ANSYS low-frequency electromagnetics analysis products are used for steady-state, time-transient, time-harmonic low-frequency electric and magnetic field studies. Users can simulate low-frequency electric currents and electric fields in conductive and capacitive systems, as well as magnetic fields resulting from currents or permanent magnets. The products also can simulate charged-particle tracing in both electric and magnetic steady state fields.

Applications involve everything from rotating machines (motors and alternators), sensors and actuators, power generators, power transformer systems and Micro Electro Mechanical Systems (MEMS). The ANSYS Emag product provides a comprehensive range of analysis features to address the diverse needs of the electromagnetics engineer, 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 where nonlinear (saturation) effects must be considered.



An example of a circuit builder model.

Product Features

High-Frequency Materials, Boundary Conditions & Effects

- ▶ Complex permittivity and permeability
- ▶ Frequency-dependent material properties
- ▶ Lossy/lossless, isotropic and diagonal anisotropic material properties
- ▶ Perfect electric and magnetic conductors (PEC and PMC)
- ▶ Impedance boundary condition (IBC)
- ▶ Perfectly matched absorber (PMA)
- ▶ Coupled heat generation from lossy dielectrics
- ▶ Rectangular, circular, coaxial, parallel plate waveguide modal source
- ▶ Plane wave source
- ▶ Surface magnetic & electric field sources
- ▶ Point, line, surface and volume current source, line voltage source
- ▶ Cavity resonant frequency
- ▶ Quality factor (Q)
- ▶ S-parameters of a network and Touchstone S-parameter output
- ▶ Joule losses, Port power
- ▶ Voltage, current and impedance
- ▶ Near and far electromagnetic field extension
- ▶ Radar cross section (RCS) & Antenna pattern
- ▶ Phased array antennas
- ▶ Specific Absorption Rate (SAR)
- ▶ ANSYS Variational Technology (VT) fast frequency sweep
- ▶ S-parameter extraction OPTION



Product Features

High-Frequency Applications

- ▶ Antennas
- ▶ General microwave components
- ▶ Microstripline circuits
- ▶ RF attenuators, loads
- ▶ Coaxial waveguides
- ▶ Radomes
- ▶ Phased array antennas
- ▶ Biomedical imaging
- ▶ RF MEMS
- ▶ SAR

Coupled Electromagnetic-Thermal Applications

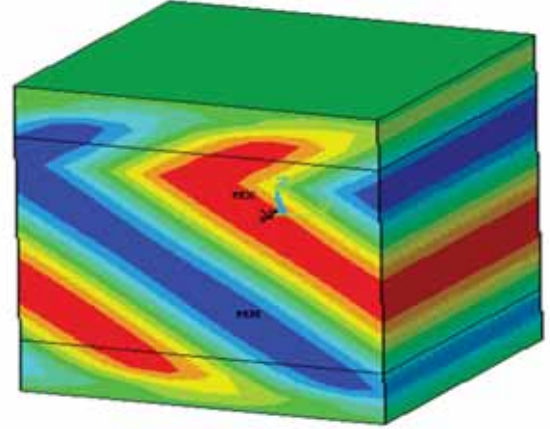
- ▶ Heat treating
- ▶ Induction hardening
- ▶ Plastic welding
- ▶ Food processing
- ▶ Ceramic sintering
- ▶ Process drying
- ▶ Film curing & drying
- ▶ Biomedical RF heating/tumor ablation
- ▶ Microwave & RF heating products

High-Frequency Electromagnetics

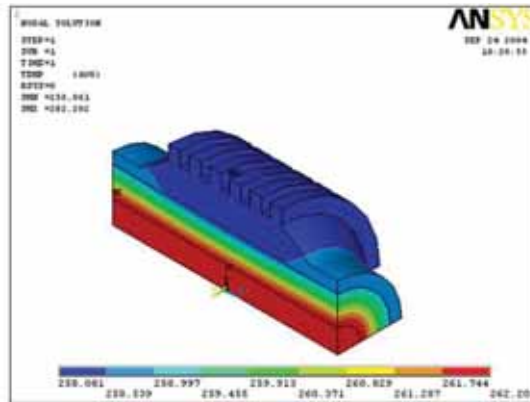
The ANSYS Multiphysics solution provides a high-frequency (or full-wave) electromagnetic simulation capability applicable to resonant, propagating, radiation and scattering phenomena in the frequency domain. Applications include the design of RF/microwave passive components and circuits, antenna design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

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 for efficient calculation of frequency-dependent parameters.



Electromagnetic wave scattering off of a periodic structure at 10 GHz.



RF heating of a coaxial load.

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 here include RF attenuators, resistive heaters, RF heaters and microwave ovens.

Please visit www.ansys.com/products for more information.