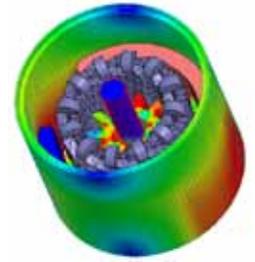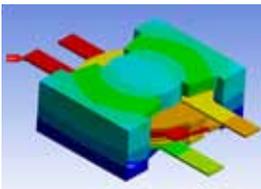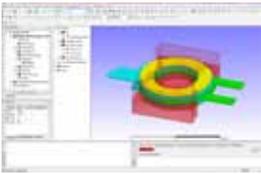# Maxwell

DC permanent magnet motor solved by Maxwell with ANSYS RMxprt

Build reliability and efficiency into your electromagnetic and electromechanical designs with ANSYS Maxwell.

Our premier electromagnetic field-simulation tool delivers the power you need for optimal performance.

Power loss of transformer solved with Maxwell, then transferred to ANSYS Mechanical™ to calculate thermal distribution

Whether you're designing HEVs, MRIs or wind turbine generators (as system, subsystem or component), your product is only as good as the field-solver technology you choose. Electromagnetic and electromechanical device designers face increasing pressure to produce smaller, less expensive, and more reliable and efficient components. Best practices suggest more simulation and fewer prototypes; ANSYS Maxwell® industry-leading field-simulation software delivers the power and capability to support your EM simulation design needs.

Maxwell includes 3-D/2-D magnetic transient, AC electromagnetic, magnetostatic, electrostatic, DC conduction and electric transient solvers that accurately solve for field parameters including force, torque, capacitance, inductance, resistance and impedance. You can automatically generate nonlinear equivalent circuits and state-space models from field parameters that may be further used in system and circuit simulation analyses. This offers the ability to perform a comprehensive analysis of the component with its drive circuit, loads and other system parameters.

**Intuitive for Quick, Accurate Solutions**

Automatic Adaptive Meshing
Using Maxwell's automatic adaptive meshing techniques, you specify only geometry, material properties and desired output. The proven technology eliminates the complexity of building and refining a finite element mesh, making advanced numerical analysis practical for all levels of your organization. The meshing process uses a highly robust volumetric technique. A multi-threading capability reduces the amount of memory used, speeding simulation.

Dynamic Link with ANSYS Simplorer
A key Maxwell feature is the ability to generate high-fidelity, reduced-order models for use in ANSYS Simplorer® multi-domain system simulation software. Using this powerful electromagnetics-based design flow, you can combine complex circuits with accurate component models to design complete high-performance electromechanical, mechatronic and power electronic systems.

Transient with Motion
Maxwell's magnetic transient solver with rigid body motion, circuit coupling and induced-eddy currents calculation uses state-of-the-art algorithms and a volumetric meshing technique — features that efficiently and accurately solve computationally intense time domain simulations, such as electric motors.
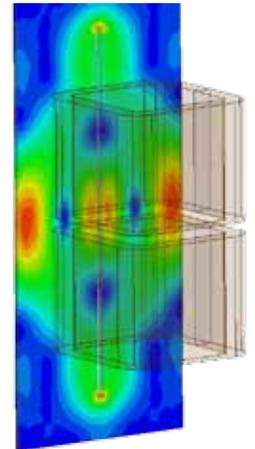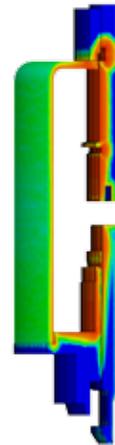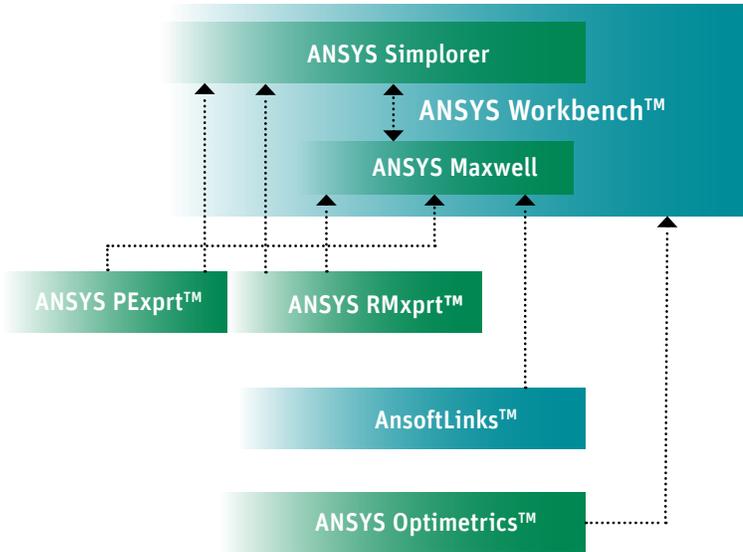
You can leverage Maxwell's accurate field calculations into circuit, system and multiphysics simulations.

Maxwell parametrically solves force vs. actuator position for more robust design and analysis.

Maxwell's eddy-current solver employs high-order vector elements to accurately compute currents.

By coupling Maxwell's magnetic transient solver with Simplorer, you can examine detailed physical interactions of electromechanical components in system design — including drive circuits, control loops and analog mixed-signal topologies.

Permanent Magnet Temperature Dependency

External magnetic fields and heating can alter magnetic properties of hard magnetic materials, leading to demagnetization. Maxwell's demagnetization analysis features enable study of permanent magnet demagnetization characteristics. Our tools combine these effects to accurately determine machine performance.

Solving Large Projects Faster

Maxwell features 64-bit user interface and solvers, enabling large-scale simulation without compromising accuracy or geometric details. Our technology incorporates multiprocessing at every stage of the process; innovative solver techniques bring incomparable speed. The end result is higher productivity.
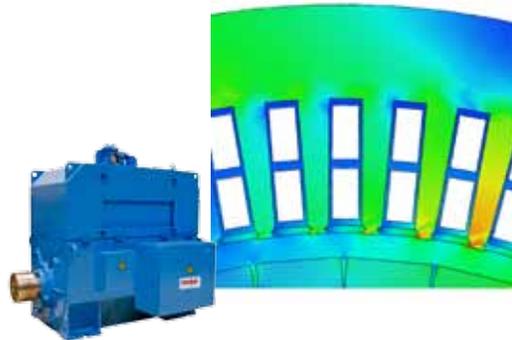
Permanent magnet generators offer high efficiency and design flexibility for wind power applications. Using Maxwell along with ANSYS Fluent® CFD software, Indar Electric developed a generator with a high efficiency rating.
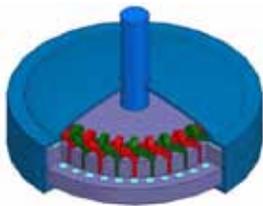
"Simulation made it possible to achieve this challenging performance goal in less than half the time that would have been required using conventional build-and-test methods. The simulation predictions correlated well with physical testing, providing confidence that Indar can use simulation to optimize its products to deliver high performance under the most demanding conditions."

Jon Vaquerizo
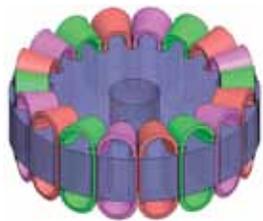Project Manager
Indar Electric

R&D teams use ANSYS Maxwell to accurately design all types of industrial devices, including motors, actuators, transformers, MRI coils, sensors and power supplies. These components are being deployed in new and diverse applications such as automotive hybrid–electric drivetrains, aerospace fault-tolerant electric power systems, alternative-energy power-generation systems, and medical devices.

Combine Maxwell with ANSYS RMxprt to create an optimal electric machine design flow.

Axial-flux machine simulated by Maxwell with RMxprt's automatic design generation

Maxwell can accurately solve the electromagnetic field produced by different winding topologies of electrical machines.

For electrical machine and generator design, you can enhance Maxwell with ANSYS RMxprt, a template-based design tool. The coupled package forms a customized machine design flow to meet market demand for higher-efficiency, lower-cost machines. Using classical analytical motor theory and equivalent magnetic circuit methods, RMxprt calculates machine performance, makes initial sizing decisions, and performs hundreds of what-if analyses in seconds. It automatically sets up the complete Maxwell project (2-D/3-D), including geometry, materials and boundary conditions for rigorous electromagnetic transient analysis.

Performance Metrics

The technology quickly calculates critical performance data, such as torque versus speed, DQ couplings, power loss, flux in air gap, power factor and efficiency.

Powerful Scripting

RMxprt integrates with third-party development programs through scripting languages such as VB script, IronPython, Tcl/TK, JavaScript™, Perl™, Excel® and MATLAB®.

Auto Design

Convenience features automatically guide your design process, determining slot size, coil turns and wire diameter, starting capacitance, and winding arrangement from given design parameters.

Pre-Processor for Electromagnetic Analysis

The design tool automatically generates a complete transfer of 3-D or 2-D geometry, motion and mechanical setup, material properties, core loss, winding, and source setup (including drive circuit) directly to Maxwell for detailed finite element analysis.

High-Fidelity System Models

RMxprt creates nonlinear equivalent circuit models that account for a machine's physical dimensions, winding characteristics and nonlinear material properties. You can use the resulting model in ANSYS Simplorer to explore electronic control topologies, loads and interactions with drive-system and multi-domain components.
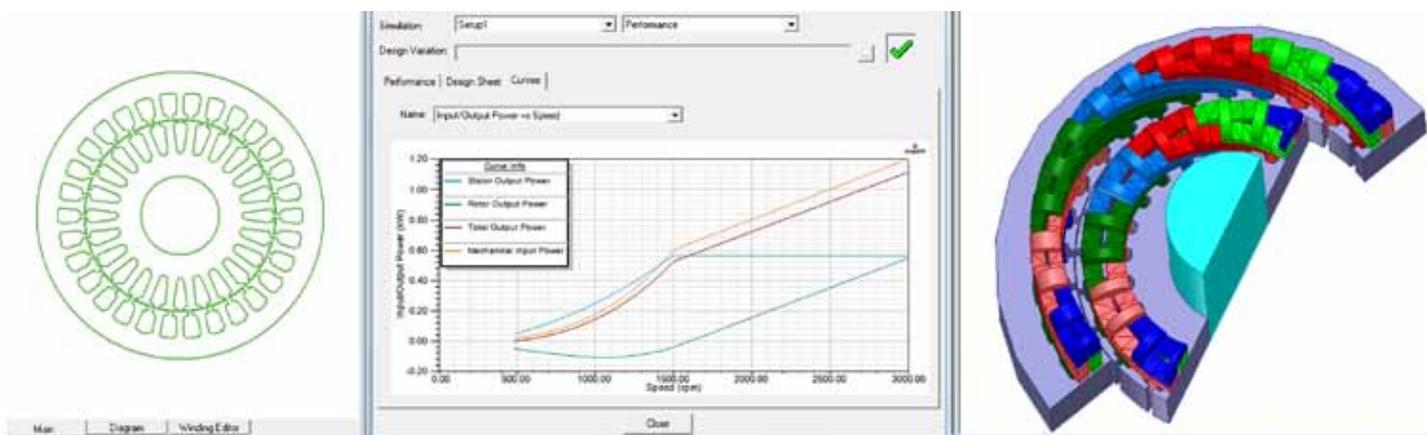
RMxprt delivers fast access to important design parameters in an easy-to-use report generator. Design sheets list all relevant input and calculated parameters; graphics display waveforms include current, voltage, torque and back EMF, and detailed winding layout. In addition, RMxprt outputs Excel-format design sheets based on the user-defined template.

Machine-Specific Template Editor
RMxprt offers numerous machine-specific, template-based interfaces, so you can easily enter design parameters and evaluate design trade-offs early in the design process.
• Rotors
• Stators
• Slots
• Running strategies
• Drive circuits

Machine Types
• Induction machines
• Single-phase motors
• Three-phase motors
• Wound-rotor motors/generators
• Synchronous machines
• Line-start PM motors
• Salient-pole motors/generators
• Non-salient–pole motors/generators

• Brush-commutated machines
• DC motors/generators
• Permanent magnet DC motors
• Universal motors
• Electronically commutated machines
• Brushless DC motors
• Adjustable-speed PM motors/generators
• Switched-reluctance motors
• Claw-pole generators
• Axial-flux machines

Output Waveforms
• Current
• Cogging torque
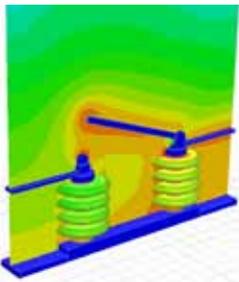• Flux in air gap

Convenient Modeling/Editing
• Wire library: ANSI/IEC wires
• Graphical winding editor
• Cross-section editor
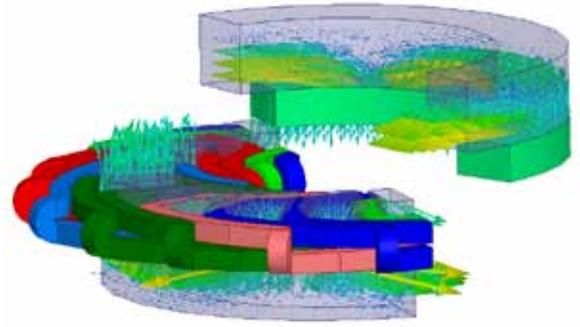
Axial magnetic field distribution on axial permanent magnet machine

Develop robust designs quickly by coupling Maxwell with industry-leading ANSYS tools, including high-performance computing.

Maxwell-simulated electromagnetic field distribution on transformer terminals

Maxwell coupled with ANSYS Fluent to determine thermal performance of induction machine

ANSYS Maxwell and related electromagnetics tools are part of our suite that delivers cutting-edge functionality — depth, breadth, a plethora of advanced capabilities and integrated multiphysics — providing confidence that your simulation results reflect real-world outcomes. The comprehensive range of solutions gives you access to virtually any field of engineering simulation that a design process requires. Organizations around the world trust ANSYS to help them realize their product promises.

Multiphysics Couplings

Maxwell is available within ANSYS Workbench, the framework for our advanced suite. An innovative project schematic ties together the entire simulation process, guiding the user through complex multiphysics analyses with drag-and-drop simplicity. Workbench shares geometry, geometry parameters and material properties with the ANSYS product portfolio, including Maxwell, to solve electromagnetic–thermal–deformation problems. For example, in a structural mechanics coupling, the two-way stress link in ANSYS Mechanical updates the deformed Maxwell mesh. You also can couple Maxwell to ANSYS CFD software to accurately explore cooling of electromechanical devices.

Robust Design

ANSYS Optimetrics adds parametric capabilities, optimization algorithms, and sensitivity and statistical analyses to Maxwell simulations. You can study the effects of geometry and materials by creating parameters for a model's dimensions and material constants. Optimetrics then varies these parameters, adjusting geometry and materials to achieve desired user-specified performance goals. Leveraging previously computed parametric simulation results within its optimizer, Optimetrics helps you to understand device characteristics over a large design space. It also leads to the best design performance that is least sensitive to manufacturing tolerances. When coupled with ANSYS DesignXplorer™, Optimetrics offers design of experiments, surface response techniques, six sigma and multiphysics system-level optimization.

High-Performance Computing

Maxwell leverages high-powered computers with multiprocessing and distributed analysis options for fast turnaround of your largest designs. Multiprocessing solves models on a single machine with multiple processors or multiple cores that share RAM. Distributed solve distributes parametric studies across a number of machines to expedite total simulation time.
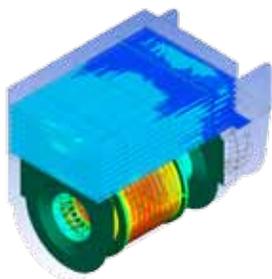
Courtesy ESSS.

5

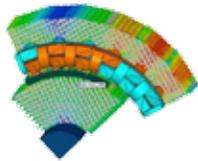## ANSYS Maxwell
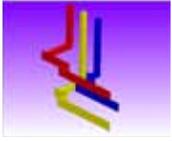
Modeling

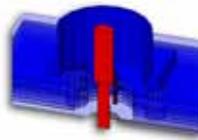*3-D ACIS-based solid modeling for electromagnetic analysis*

RMxprt for electric machine geometry creation

Meshing

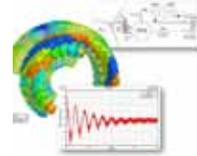*Automatic adaptive meshing technique*

Optimization

Optimetrics adds parametric, optimization, sensitivity and statistical analyses.
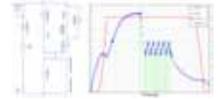
System Simulation

Simplorer for high-performance system design, modeling, analysis and optimization

Solvers

Transient with motion and quasi-static solvers

Circuit Model Auto Generation

Automatic extraction of equivalent circuit and state-space models from electromagnetic field results for use in circuit and system simulation
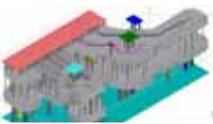
Pre-Processing   **Simulation**   **Post-Processing**   **Archive**

## Other ANSYS Engineering Simulation Capabilities

MCAD

AnsoftLinks for MCAD facilitates the transfer of 3-D geometry from mechanical CAD (MCAD) packages using common file formats, such as IGES, STEP, ACIS, Parasolid®, ANSYS Mechanical™, NASTRAN®, Pro/ENGINEER®, AutoCAD®, CATIA® and Siemens NX™.

Integration

ANSYS Workbench is the framework for the industry's broadest and deepest suite of advanced engineering simulation technology. It delivers unprecedented productivity, enabling Simulation-Driven Product Development™.

Multiphysics
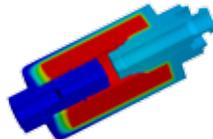
To help ensure a successful product, R&D teams must accurately predict how complex products will behave in a real-world environment. The ANSYS suite captures the interaction of multiple physics: structural, fluid dynamics, electro-mechanics and systems interactions. A single, unified platform harnesses the core physics and enables their interoperability.

HPC

High-performance computing enables creation of large, high-fidelity models that yield accurate and detailed insight. ANSYS offers scalable solutions and partners with hardware vendors to ensure that you get the power and speed you need.

Design Optimization
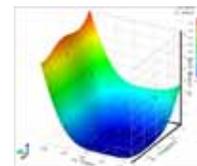
Good design starts with identifying the relationship between performance and design variables. ANSYS DesignXplorer enables engineers to perform design of experiments (DOE) analyses, investigate response surfaces, and analyze input constraints in pursuit of optimal design candidates.

Data Management

ANSYS EKM™ addresses critical issues associated with simulation data, including backup and archival, traceability and audit trail, process automation, collaboration and capture of engineering expertise, and IP protection.

ANSYS is dedicated exclusively to developing engineering simulation software that fosters rapid and innovative product design. Our technology enables you to predict with confidence that your product will thrive in the real world. For more than 40 years, customers in the most demanding markets have trusted our solutions to help ensure the integrity of their products and drive business success through innovation.

MKT 107