It is now simple to be precise

J MAG is a comprehensive software suite for electromechanical equipment design and development. Powerful simulation and analysis technologies provide a new standard in performance and quality for product design.

Capture complex phenomena and gain valuable insights.

J MAG’s “Automatic Mesh,” which uses superior geometry recognition functions, provides both high analysis speed and excellent accuracy.

More information and free trial available...
jmag-international.com
About J MAG

J MAG is a simulation software for electromechanical design and development. Many companies and universities have supported and used J MAG since 1983. J MAG can accurately capture and quickly evaluate complex physical phenomena inside of machines. Users inexperienced and experienced in simulation analysis can easily perform the simple operations required to obtain precise results.

Markets

JSOL is dedicated to keeping J MAG on the forefront of simulation technologies. This translates into a commitment to extend and improve J MAG’s internal capabilities. At the same time, JSOL recognizes that it is important to develop J MAG’s external capabilities. JSOL’s partnerships with leading companies ranging from material manufacturers to software developers have made J MAG into a powerful multiphysics analysis package that adds value to many industries’ design and development processes.

Automotive

Develop more accurate system simulations

As automobiles become more complex, it is necessary to develop accurate system simulations that can account for interactions between multiple sub-systems. For example, increasing a hybrid vehicle’s efficiency requires understanding how the electronic controls interact with the drive motor.

Home Appliances

Estimate the Actual Performance of Products in Their Operating Environment

J MAG’s advanced multiphysics simulation technology has been implemented by engineers to quickly and accurately predict the actual performance of various home appliances.

Electric Power Facilities

Performance Evaluation under Extreme Operating Conditions

J MAG is used by engineers to perform rigorous tests that simulate potential fault conditions. Components can then be improved to reduce the chances of failure both under daily and extreme operating conditions.

Digital Equipment

Analyze Components more thoroughly than Physical Testing

J MAG’s unique solutions are being applied to investigate digital components that are too small or difficult to examine by conventional test methods.

Factory Automation

Investigate Machine Performance Based on actual Control Algorithms

J MAG is being utilized to investigate numerous control/machine design possibilities. J MAG is also being linked to control circuit simulators which allow companies to test a virtual machine in a real-time operating environment.

Applications and Analysis Functions

J MAG is a multi-domain simulation tool that can be used for electromagnetic, structural, thermal, and control simulations. Companies today, however, rely on multiple software packages that have been optimized to model very specific phenomena. This is why J MAG has an “open” interface allowing you to integrate J MAG seamlessly within your analysis environment. We have also actively pursued partnerships with many leading analysis software companies to make it even easier to create multi-domain simulations.

<table>
<thead>
<tr>
<th>Typical Applications</th>
<th>Analysis Functions</th>
<th>Interfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motors</td>
<td>Magnetics</td>
<td>Major CAD systems</td>
</tr>
<tr>
<td>Generators</td>
<td>Electrostatics</td>
<td>Drive/control simulators</td>
</tr>
<tr>
<td>Transformers</td>
<td>Structural</td>
<td>Optimizers</td>
</tr>
<tr>
<td>Reactors</td>
<td>Thermal</td>
<td>Other CAE tools</td>
</tr>
<tr>
<td>Solenoids</td>
<td>Multi-physics</td>
<td>etc.</td>
</tr>
</tbody>
</table>

J MAG Group

J MAG Group’s mission is to provide valuable solutions for the design and development of electrical devices through simulation technology. J MAG Group is comprised of four internal teams: sales, support, marketing, and development. Together with our technical partners we have created a global network to help J MAG deliver the best possible solutions. Through our global network, J MAG Group provides comprehensive services including software support, training, and development.
Motor Designing Tool
JMAG-Express
- Set up a complete analysis in minutes, generate the results in seconds.
- You can then export a model to JMAG Designer for further analysis.

Next-generation Analysis Tool
JMAG-VTB
- Reduce the set up time by applying a pre-defined analysis scenario to your model.
- You create the model and define the analysis goal; JMAG takes care of the set up and automatically generates the specified results.
- You can also set a custom analysis scenario and store it in the Scenario Database.

Simulation Software for Electromechanical Design
JMAG-Designer
- JMAG-Designer is a high-speed, high-precision FEA software tool.
- An intuitive interface and precise modeling technology with a wide variety of results displays are built in.
- Multifaceted evaluation of various design ideas is made possible by freely manipulating geometry, material properties, and drive conditions.

MBD for motor drive systems
JMAG-RT
- JMAG-RT creates high-fidelity plant models that closely approximate actual machine performance. With the RT model, the simulation can now account for complex phenomena such as magnetic saturation and high frequency harmonics.
- Since the plant model is operating in the drive simulation, analysis times are still very fast.

The Analysis Tool for Design Engineers
JMAG-Bus
- Construct an interface based on JMAG-Designer that fits your design operations.
- It is Web based, so it can be used on PCs that do not have JMAG installed.

Electromagnetic Field Analysis with CATIA
JMAG for CATIA V5
- JMAG can be run on CATIA V5.
- Simplify the analysis process by using your existing geometry.
- Perform 2D and axisymmetric analyses simply by specifying cross-sections, and reduce calculation costs.
The Four Concepts Behind J MAG

Precise Analysis

Finite Element Analysis allows engineers to visualize the unseen world of electromagnetic fields just like scientists use a microscope to reveal details that are too small to see with the naked eye. Exploring complex phenomena can lead to new avenues of innovation. This exploration is made possible through accurate and precise modeling which can reproduce complex phenomena occurring within a design. Accurately simulating complex phenomena requires precision, since the most accurate model is useless if the results cannot be reproduced. A precise tool can accurate predict the effect of slight changes in geometry or how a similar design will perform. J MAG provides the latest technological advancements to precisely model geometry, material properties, as well as the effect of thermal and structural phenomena associated with electromagnetic fields. With J MAG, it is possible to investigate a design’ s most basic elements and test new approaches to maximize performance.

Modeling Geometry
- Direct open link to CAD
- Internal Geometry Editor
- Automatic Air Gap/Insulation
- Automatically model rotor Eccentricity
- EdgesCreate end windings
- Automatically Create 2D Cross Sections from 3D

Modeling Material
- Extensive Material Database
- Lamination/Anisotropic Property Settings
- Magnetization/ Demagnetization
- Stress Dependency/ Temperature Dependency
- Hysteresis
- Magnetostriction

Generating Mesh
- Automatic Mesh
- Adaptive Slide Mesh
- Slide Mesh Option
- Layered Mesh
- Thin Sheet Mesh
- Skin Depth Mesh
- Patch Mesh
- Automatic Air Mesh
- Rotating Machine Mesh
- Manual Mesh Editor
- Local Mesh Size Specification

Running Analyses
- Link to Control Circuit Modeler
- Thermal Analysis
- Structural Analysis
- Iron loss Calculation
- Inductance Calculation
- Sound Pressure Calculation

High Speed Processing

In today's competitive product development environment, one of the biggest constraints most companies face is time. Tight time lines and short development cycles prohibit a trial and error approach to product development. In many cases, various components are developed in parallel which requires extensive collaboration between multiple groups. Meeting the deadline can only be achieved through accurate analyses that include critical design details.

J MAG was created with this type of process in mind. Often times the solving a model is time consuming, but J MAG uses numerous tools to reduce analysis time. Since J MAG was purpose built for electromagnetic FEA, the solver can leverage proprietary algorithms that reduce analysis time and increase accuracy. J MAG can also use parallel and distributed processing to handle large and/or multiple analyses. Reducing analysis time gives you more time to focus on all the other aspects of a development cycle.

High Speed Processing
- Highly efficient iterative solver for both 2D and 3D models
- Parallel solver
- Subcycling coupled analysis
- Indirect or direct link with control/circuit modeler
- Time period explicit error correction method
- Lamination loss

Distributed Analysis
- Distributed processing
- Snapshot analysis
- Remote execution
High Productivity

High Productivity can mean different things to different people. For some JMAG users, their goal is to generate as many viable concepts as possible. For other JMAG users, High Productivity means fully investigating a complex phenomenon on a single device. Because of this, JMAG does not have a "one size fits all" approach to finite element analysis. We recognize that every JMAG users’ goals are different and so we want to provide products that adapt to their needs.

We also recognize that advanced simulation tools often have elaborate interfaces to provide users with many complex options. This can be daunting to new users and tedious to experienced users. JMAG’s philosophy is focused on providing a user interface that is capable of quickly creating advanced simulation analyses, but that is still intuitive so that even new users can quickly create a working model. In addition to an easy to use interface, JMAG also offers support tools and feedback functions that guide users through each analysis.

Intuitive Graphical User Interface
- Drag-and-Drop Condition Settings
- Project tree to organize multiple models
- Circuit Editors for Electric and Thermal Circuits

Information and Help Resources
- Online Help
- Step by Step tutorials “Self Learning System”
- Application Notes
- Search function of all JMAG materials "JMAG Portal"

Model Feedback
- CAD Diagnosis System
- Condition Checks
- Analysis Monitor

Automation
- Parametric Calculation
- Optimization
- Analysis Templates
- Analysis Reports
- Scripting
- Universal Batch System

Open Interface

JMAG is an integrated suite that offers an optimal environment with all the tools required to perform a simulation. But to extend analysis capabilities even further, JMAG has an open interface that has been designed to work together with multiple 3rd party software programs. JMAG users can quickly configure a model incorporating contributions from various software programs. In most cases these links are seamless to the user and these links can even act as a bridge between multiple divisions within a company. For instance by using JMAG-RT, you can create a high fidelity electromagnetic machine model that can then be incorporated as a “block” in a control/circuit design program. JMAG’s compatibility with other software enhances the design possibilities and allows users to leverage existing software.

CAD Link
- CATIA
- Pro/ENGINEER
- SolidWorks
- NX

Script
- VB Script
- Python
- JScript

Link with Real Time Simulator
- OPAL-RT
- DSP Technology
- dSPACE
- National Instruments

Link with System Level Simulator
- MATLAB/Simulink
- PSIM
- LabVIEW
- GT-SUITE
- MapleSim (preliminary)
- SABER (preliminary)

Link with Other CAE Systems
- Nastran
- Abaqus
- LMS Virtual.Lab
- AcuSolve
- MpcCCI
- mode FRONTIER
- Optimus
- SPEED
- With Multi-Purpose File Export Tool, it is now possible to link with other CAEs.
The advantages of J MAG to electric machine analysis have been proven time and again. Even though electric machines are considered mature products, they still face new demands for higher performance. These demands have increased competition among machine designers to extract the most performance from a design. After more than 100 years, most of the easy innovations have already been made and deriving further performance gains requires finite element analysis (FEA) to identify previously overlooked or underestimated aspects of machine design. Since J MAG’s release, it has been utilized in a number of motor development projects around the world. Our accumulated knowledge and experience in motor design enables us to provide powerful yet easy to use simulation technologies.

Capabilities

Evaluate complex phenomena such as thermal demagnetization and vibration in addition to basic characteristics such as induced voltage, torque, and inductance.

Typical Analyses:

- Obtain induced voltage, load torque, cogging torque, inductance, flux linkage, iron losses, coil losses, magnet loss, permeance, parameter sensitivity, equivalent circuit model extraction, heat generation, temperature distribution, eccentricity, stress, vibrations, radiated sound, magnetization, demagnetization, and skew effects.

Features Supporting Motor Design

A full range of features allow sophisticated analyses to be performed with ease.

J MAG-Express / Motor Template Tool
- Use a built-in template to specify fundamental design parameters such as geometry, materials, winding pattern and circuit excitation.
- Model creation takes minutes, and basic performance metrics such as torque vs speed and efficiency are generated in seconds.
- Users can also create custom templates for their own machines.
- Batch process parametric calculations.
- Templates for PMSMs, IMs, SRMs, brush motors, and universal motors are all included.

Meshing
- Accurate machine analysis requires an extremely high-quality mesh and J MAG’s mesh was specifically developed for machine analysis.
- No matter what geometry you use, just a few simple settings enables the automatic mesh generator to create a high quality mesh.

Coil Modeling
- Coil settings are easy to apply through an automatic coil winding tool or by manually specifying the coil’s input and output slot.
- Influence from the leakage flux on the coil ends or the surrounding housing can be precisely evaluated.

Loss Calculation
- The advanced material database allows users to automatically segregate iron losses into eddy current and hysteresis losses.

Coupled Control/Circuit Simulations
- Evaluate the actual drive effects by connecting the machine model to a circuit model.
- Model arbitrary circuit networks using inductors, capacitors, resistors or diodes.
- Perform analyses by linking to power electronic simulators such as PSIM and MATLAB/Simulink.

Material modeling
- The material database contains about 700 types of material properties (BH and loss) directly provided by the material manufacturers.
- It is also possible to create a custom material and add it to the database.
- J MAG can account for anisotropy and stress in electrical steels.
- Alternating demagnetization and thermal demagnetization modeling in magnets is also possible.

Efficiency Maps and Speed vs Torque Curves for Motors
- Speed versus torque characteristics can be calculated and efficiency maps generated by simply specifying the control type in the J MAG-RT Viewer for machines models created using the J MAG-RT tool.

Inductance Calculation
- It is possible to automatically calculate a machine’s inductance.
- A special tool is included that calculates d/q axis inductance for permanent magnet motors.
Steps for Motor Design Using J MAG

**Concept design**

**Basic design**

**Detailed design**

**J MAG-Express Quick mode**
- Extract machine performance metrics in seconds by specifying geometry, materials, and circuit parameters.
- Basic performance metrics are automatically displayed.

**J MAG-Express Power mode**
- Specify the goals of an analysis and J MAG sets up the FEA and then automatically extracts the necessary parameters.

**Built-in database**
- It is possible to search model data by using design parameters and calculation result values, making it easy to compare results.

**J MAG-Designer**
- Perform in-depth model analysis and analyze complex phenomena more accurately.

**J MAG-RT**
- Generate machine models for 1D simulators. (RT file output)

Control circuit simulator studies using Hardware in the Loop Simulation (HILS) are also possible.

Display efficiency maps in J MAG-RT Viewer.

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**Share geometry and conditions between J MAG-Express Quick mode/J MAG-Express Power mode/J MAG-Designer**

<table>
<thead>
<tr>
<th>Tool</th>
<th>Target motor</th>
<th>Evaluation item</th>
</tr>
</thead>
</table>
| **J MAG-Express Quick mode** | PMSM, IM, SRM | - Simple calculation  
- Speed-Torque curve  
- Torque/efficiency  
- Copper loss/iron loss  
- Inductance  
- Voltage  
- Magnetomotive force distribution |
| **J MAG-Express Power mode** | PMSM | - Basic characteristics  
- No-load  
- Load  
- Inductance  
- Efficiency  
- Iron loss analysis considering PWM carrier harmonics  
- Magnet eddy current loss analysis that accounts for PWM  
- Segregation analysis of torque components |
| IM                    | | - Equivalent circuit parameters  
- Drive characteristics  
- Torque characteristics  
- Line start analysis |
| SRM                   | | - Psi Characteristics  
- Static Characteristics  
- Drive Characteristics  
- Dynamic Characteristics |
Transformers are required to convert power with little loss and at a high efficiency level. For large transformers the amount of energy handled and their critical role to supporting industrial infrastructure require high efficiency, but these transformers must also be extremely safe. In recent years strict noise requirements have been imposed due to their use in residential neighborhoods.

Most problems with large transformers occur due to physical phenomena acting on external components. For example, electromagnetic flux leakage resulting from high capacitance can induce stray losses in structural components. Another example is that insulation durability is determined according to the maximum electrical field. Other problems can occur due to vibration driven by electromagnetic forces and magnetostriction.

JMAG not only simulates these phenomena and makes it possible to perform quantitative evaluation but also helps pinpoint the true nature of problems. Through these analyses JMAG contributes to the cost-reduction of large transformers by avoiding the construction of multiple costly prototypes.

**Analysis features**

JMAG uses simulations to accurately reproduce various physical phenomena caused by heat generation and vibration from a transformer’s insulation resistance. JMAG’s software can analyze the basic physical quantities of electric field distribution and magnetic flux density distribution. In addition to these basic analyses, JMAG can also evaluate many other phenomenon, including every type of loss (such as iron and copper losses), electromagnetic vibrations in the coil, and even audible noise.

**Evaluating insulation durability**

- JMAG can evaluate a transformer’s insulation resistance as a function of local electric field distribution.

![](electric_field_distribution_in_the_insulation_film)

**Evaluating electromagnetic force produced in the winding**

- The large inrush current that flows when power is applied to the transformer induces a large Lorentz force on the winding. JMAG makes it possible to evaluate local wear on the insulation film during high Lorentz force operation.

![](lorentz_force_distribution_in_the_winding)

**Evaluating leakage flux and stray loss**

- JMAG can accurately model leakage flux, which is nearly impossible to evaluate in a numerical model. Modeling the leakage flux allows users to evaluate stray loss distribution in the surrounding structural components. This enables you to create designs accounting for the position of the transformer and its structural members.

![](magnetic_flux_density_distribution_on_thetankwall)

**Vibration/noise**

- By obtaining electromagnetic vibration and magnetostriction vibration, it is possible to compare how much each contributes to the total vibrations.

![](electromagnetic_vibration)

**Iron loss distribution produced in the core**

- In addition to modeling the iron loss distribution in a transformer core, it is possible to divide the core's iron losses into hysteresis and joule losses, and evaluate their individual contributions to the total losses.

**Heat generation phenomenon**

- It is possible to evaluate temperature distribution in the transformer and surrounding components by modeling the iron loss in the core, the copper loss in the winding, and the stray losses.

**Features Supporting Transformer Design**

**Material model**

- Possible to create a model that accounts for the lamination factor in the in-plane and out-plane direction of the magnetic steel sheets, as well as accounting for the properties of the easy and the hard axes.
- Structural steel materials properties are also included in the JMAG Material database.

**Meshing**

- Skin mesh generation is required to accurately evaluate the eddy currents forming stray losses. JMAG's automatic mesh function makes it possible to specify the element size of parts as well as specifying the element size of the part's skin mesh. The ability to specify the element size of a part separately from the skin depth size can help reduce the number of elements required in the mesh.
In recent years, metal heating through electromagnetic induction has been applied to many applications, from high-frequency induction heating to preheating the target metal in metal-surface treatment. However, the areas generating heat shift as the temperature rises. Previously, engineers have only had two options to capture these complex phenomena: evaluate the inside of the work piece based on the temperature measured on the surface or estimate the temperature by evaluating the component’s cross-section after heating. J MAG provides new avenues to capture and visualize this complex phenomenon.

Capabilities

Evaluate the heat generation and temperature changes due to the temperature distribution. Examine the optimal arrangement for the heating coil and complicated workpieces. The heating coil can be further improved by analyzing eddy current formation and magnetic flux distribution which cause the temperature to rise in unexpected areas.

Temperature distribution on the work piece

- Temperature distribution in each part of the work piece is being obtained. Please confirm the range and depth that reach to the target temperature on the work piece surface.

Current density distribution

- In high-frequency induction heating, eddy currents in the work piece and coil cause a non-uniform current distribution. JMAG can simulate non-uniform current distribution even in work pieces with complex geometry.

Heat efficiency

- The electric energy in the heating coil is converted to thermal energy due to electromagnetic induction. Input power and output heat are calculated which allows users to make an accurate estimate of the necessary power input.

Magnetic flux leakage

- The magnetic flux flowing around the heating coil can be evaluated.

Temperature rise at defined observation points

- It is possible to predict temperature versus time and therefore determine the time required for a workpiece to reach a target temperature. Also, it is possible to know the rate of temperature rise at defined observation points.

Heat generation distribution

- As the temperature rises, the material properties vary which then effects the thermal distribution. These changes are common indicators if the coil is designed properly.

Coil resistance and inductance

- High-frequency current has a non-uniform distribution. This causes non-uniform heating of the components which can then alter the material’s resistivity. Increasing temperature also alters the electrical properties to the inductance also varies.

Application example

- High-frequency induction heating of a gear
  Perform a high-frequency induction heating on the outer surface of a gear with the goal of predicting the mechanical deformation due to thermal expansion from the rising temperature.

- High-frequency induction heating of a crankshaft
  While rotating the crankshaft, high-frequency induction rapidly heats the contact part which then results in a non-uniform temperature distribution.

- High-frequency induction heating of a constant-velocity joint
  This analysis investigates a surface heat treatment on the concave portion by placing the heating coil inward.

- Printer fixing unit
  When the rotating roller is heated with a fixed coil, the temperature in each part varies depending on the initial position.

- IH cooking heater
  Determine the optimal placement of heating coils so that the iron pot experiences uniform heating of the bottom surface. It is also necessary to evaluate magnetic leakage flux that heats structural components.

- Induction furnace
  This study investigates the relationship between different magnetic material positions and magnetic flux leakage.
In addition to the increased focus on power generation from renewable energy sources, traditional energy sources such as thermal power and hydro power are also being investigated. All these applications require developing efficient generators. Improving the efficiency of large generators requires developing complete new technologies and not just incrementally improving existing technologies.

Two critical phenomena in large generators are reducing stray load loss and reducing local eddy current loss. These issues require accurate analysis and investigation. Everything from material settings to mesh generation will impact the accuracy and analysis time for these solutions. J MAG’s powerful solver and highly adaptable mesh are well suited for these types of investigations.

**Analysis Features**

Reducing losses in high efficiency generators require identifying places where stray losses occurs, and also understanding eddy current distribution. J MAG has the ability to accurately simulate magnetic flux and eddy current distribution and to then test a design’s ability to reduce leakage flux and minimize unwanted eddy currents.

### Power generation properties

- Confirm power waveforms, voltage waveforms and current waveforms and make it possible to visualize physical quantities such as magnetic flux density distribution, iron loss distribution and eddy current distribution.

### Eddy current loss of the armature

- The armatures of turbine generators often have slits to reduce eddy currents on the ends. This also requires a 3D analysis to capture, which is possible with J MAG.

### Stray load loss caused by coil end turns

- Large generators often have large end turns that can cause stray loads. Accurate evaluation of the end turns requires a 3D model. Many software packages are not able to quickly solve large 3D models, but J MAG’s proprietary solver can still quickly solve even large 3D models.

### Loss of the damper ring

- Hydro power generators have low rotational speed and multi-pole structures. This necessitates the use of dampers on the rotor surface to stabilize generator speed which in turn which stabilizes output voltage. The effectiveness of these dampers and their losses can be accurately evaluated using J MAG.

### Model creation functions that give you freedom

#### Powerful mesh generation function

- Large generators require large analysis models in order to capture detailed geometry.
- J MAG can use extruded mesh to reduce the number of elements in these large 3D models. Also, complex geometries may have inconsistencies in the CAD data, but J MAG’s mesh generation function can tolerate small inconsistencies.

#### Modeling functions that aid the analysis of large models

- It is possible to create 2D sections from 3D CAD geometries.
- J MAG also has a tool to automatically model complex coil-end geometry. Modeling the coil end turns is necessary to accurately predict stray load losses.

#### A high-speed solver that can handle large models

- J MAG’s solver uses proprietary algorithms to reduce analysis time. These algorithms also reduce the amount of computer memory required which also increases the analysis speed.
- J MAG can also use parallel processing as well as adding in the computer’s GPU to further reduce the analysis time.
Circuit Breaker Design

Circuit breakers are required to have high performance because of the high capacity and high voltage of transformers. The basic characteristic of breakers is to interrupt fault current. In order to fully interrupt the current, the speed of electric arc blow off is critical.

A circuit breaker’s contact design allows the electric arc to be magnetically dissipated. As the arc is dissipating it will induce a Lorentz force. J MAG’s high accuracy magnetic field analysis captures the magnetic field between electrodes, making it possible to obtain the Lorentz force. The physical phenomena of complex contact structures can be visualized, which will lead to improved circuit breaker designs.

Analysis Function

J MAG accurately captures the Lorentz force of an electric arc by simulating the current distribution flowing inside the breakers. Also, by coupling the J MAG model with Computational Fluid Dynamics (CFD) software, it is possible to dynamically capture the electric arc as it is being dissipated.

**Current density distribution**
- Current density distribution can be visualized in complex contact terminal structures.

**Magnetic flux density distribution**
- In order to magnetically blow off the electric arc, it is necessary to design a contact that generates a magnetic field which bisects the electric arc.

**Lorentz force**
- By evaluating the Lorentz force, it is possible to evaluate the electric arc blow off force on the electric arc itself and electromagnetic repulsion of the contacts.

**Coupling with thermal fluid analysis**
- By using the MpCCI link, J MAG can be coupled with CFD software. Coupling makes it possible to dynamically visualize the electric arc.

**Actuators**
- To account for the mechanical structures, the model must include the equation of motion for the contacts.
- By including the circuit coupling and equation of motion, it is possible to accurately evaluate the performance of switch-driven mechanisms.

[Images of current density distribution near contact, Lorentz force density distribution, and Coupling with thermal fluid analysis with MpCCI link]
J MAG- VTB (Virtual Test Bench)

J MAG- VTB is a next-generation analysis tool that makes it possible to easily run complicated analyses including multi-domain studies. J MAG- VTB is equipped with a wide range of scenarios. Choose the scenario that is similar to your analysis objective and J MAG will take care of setting up the actual studies to achieve your final objective.

Features

Analysis “know-how” and workflows are built into each scenario so that your intended analysis can be set up instantly. Of course VTB can control an analysis in J MAG Designer, but you can also integrate 3rd party software into the analysis. Once the simulation is complete, you can quickly pull results onto a dashboard to evaluate the design.

Dashboard

- Results from J MAG- VTB are automatically displayed on the dashboard.
- Analysis results appear in a list so it makes possible to streamline results processing.
- Multiple dashboards can be displayed at the same time to facilitate comparison.
- It is possible to start J MAG- Designer from the dashboard and carry out more in depth studies based on the model that J MAG VTB created.

Analysis database

- All the data from the analysis such as geometry data, calculation data or scenarios are managed in the analysis database.
- This reduces the amount of data that you must post process in external spreadsheets.
- It is possible to search within the database results.

Workflow

- Each process during the analysis is shown in the workflow.
- Process status is displayed in different colors in the workflow so it is easy to confirm.
- It is possible to start software such as J MAG- Designer from the workflow, and analysis results are easily confirmed.

Extensive scenario

- Analysis know-how and analysis steps are incorporated into the scenarios.
- Common scenarios for devices such as machines, transformers, induction heating or injectors are already included in J MAG.
- JSOL will continue to add new scenarios.
- It is possible to customize an included scenario or create your own scenario.

A motor with 4 poles and 24 slots
The demands on electric device performance are growing each year. Maximizing performance requires mastering CAE to optimize designs. J MAG provides a wealth of features to support rapid design optimization.

Features

J MAG’s parametric analysis and optimization calculation functions can evaluate a large numbers of designs. The results analysis and sensitivity analysis functions provide information to guide design improvements.

<table>
<thead>
<tr>
<th>Parametric analysis</th>
<th>Optimization calculation</th>
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</thead>
<tbody>
<tr>
<td>J MAG automatically creates analysis data from geometry changes or design variables, and allows you to evaluate the influence on performance.</td>
<td>Optimum solutions are obtained from the defined design variables, target functions, and constraint conditions according to the response surface method.</td>
</tr>
<tr>
<td>Summary reports are automatically created and it is possible to generate multi-case reports to compare multiple cases.</td>
<td>Supports multi-objective optimization.</td>
</tr>
<tr>
<td>Sensitivity analysis</td>
<td>All input parameters such as geometry, material properties, or mesh can be defined as design variables.</td>
</tr>
<tr>
<td>Calculates the sensitivity of the results to each design variable. Multiple target functions can be set with an optional weighting for each function.</td>
<td>The design variables obtained using a sensitivity analysis can be easily used in optimization calculations.</td>
</tr>
<tr>
<td>Results analysis</td>
<td>It is possible both to confirm the solution distributions in Pareto charts and display differences in contour plots.</td>
</tr>
<tr>
<td>Fourier Transform display of harmonic components of the results Displays the contour distribution and vector distribution for each harmonic showing the of each harmonic to the result.</td>
<td>Distributed processing</td>
</tr>
<tr>
<td>Display of differences between multiple results Differences in the distribution between selected cases and studies are displayed, allowing confirmation of geometry and parameter contributions to results.</td>
<td>Parametric studies with hundreds or even thousands of cases can be accomplished on a computer network, this will reduce the total calculation time.</td>
</tr>
</tbody>
</table>
JMAG Simulation Technology

JMAG is working improving modeling and increase accuracy.

Mesh

Opening a CAD model in JMAG makes it possible to generate mesh that accurately captures various electromagnetic phenomena. JMAG has many unique mesh generation functions like tools that automatically recognize geometry and improve accuracy without sacrificing analysis speed.

**Section analysis**
- Specifying Section Analysis in a 3D CAD model where the calculation conditions have been set makes it possible to run an analysis of a 2D cross-section.

**Slide mesh/Rotating machine mesh**
- It is possible to automatically generate mesh for calculating cogging torque without complex settings.
- Rotating machine analysis is also supported by automatically generating an air gap mesh.
- Analysis accuracy and speed are combined.
- Rotor and stator skew are also supported.

**Skin depth mesh**
- The Skin Depth mesh function allows users to accurate model eddy currents concentrated near the model surface.

**Patch mesh**
- Patch mesh can be used on geometries with complex motion paths. In a Patch Mesh, the model is re-meshed at each analysis step.
- Patch Mesh can be applied to models such as spindle motors and electromagnetic relays.

**Adaptive mesh**
- JSOL’s unique development methods run high-speed adaptive analyses for rotating machines that are highly accurate. They can achieve speeds over ten times faster than traditional methods.

**Automatic air mesh**
- Generate a mesh for only the air region without changing an existing mesh.
- It is possible to create a mesh for magnetic field analysis based on a mesh that was created with a different mesh program.

**Thin shell mesh/Layered mesh**
- This mesh can be used for an extremely thin plate model in the analysis space, such as a shield or chassis panel. The thin shell mesh feature can generate a sufficiently large mesh in the in-plane direction based on the layered mesh that is generated in the thickness direction.
- This mesh generates a parallel layered mesh on the specified solid face. This is a convenient function when analyzing a laminated steel sheet in detail.
High Speed Solver

The latest version of JMAG has even faster solvers. JSOL has greatly improved the speed for transient response analyses with our proprietary algorithms. JSOL has also incorporated solver techniques such as the time period explicit error correction method.

Large-scale model calculations

- **Parallel solver**
  Time is important when running a large-scale analysis. JMAG has parallel calculation features that make shorter analysis times a reality:
  - Shared memory (SMPI)
  - Distributed memory multiprocessing (SMP)
  - Cluster support
  - Also supporting GPUs

![Graph showing speedup by parallel solver](image)

Calculation of multiple models

- **Distributed calculation**
  Multi-case analyses are required for a parameter survey that changes geometry and material properties. JMAG has a distributed calculation feature that automatically distributes multi-case analyses to up to several hundred computers.

![Network diagram showing distributed calculation](image)

A stable analysis for every problem

- **Iterative solver**
  The latest version of JMAG improves the convergence of ICCG and nonlinear calculations. The subcycling method also makes it possible to solve coupled analysis problems with different time steps quickly and accurately.

![Graph showing iterative solver convergence](image)

Analyze complicated physical phenomena fast

- **Time period explicit error correction method (EEC)**
  This function uses the temporal periodicity of varying fields in a magnetic field analysis to suppress the transient state produced at the beginning of a transient analysis. This calculates a steady state solution in a smaller number of steps. JSOL's version of the EEC function is effective for these kinds of devices, as well.

![Graph showing EEC method](image)

Modeling

The accuracy and reliability of a simulation depends on the way of modeling the analysis target. JMAG can more accurately model complex physical phenomena (multiphysics) such as electromagnetic fields, heat, structure and fluids and perform an analysis of them. Also, it also includes methods that can create high-level material models of magnetization, demagnetization, temperature dependency, hysteresis, which take into account their behavior on a small scale and are generally considered to be difficult.

Multi-physics

- Induction heating press fabrication analysis
- Magnetic field/structural two-way coupled analysis

![Graph showing multi-physics analysis](image)

Material modeling

- The JMAG lamination model carries out highly accurate eddy current losses during transient calculations in 2D as well as 3D models.
Model-based Development of Motor Drive Systems J MAG-RT

**New motor drive design methodology is required to meet the increasing demands placed on electromechanical machines. Model-based development facilitates a collaborative design approach between machine and control designers. "J MAG-RT" is capable of completing the bridging the gap between these two development teams. J MAG RT creates a block for control development based on the machine characteristics determined by the motor designers.**

- Motor drive system design and optimization that imports real motor properties
- Reducing setbacks and improving efficiency in motor drive system development
- Motor controlled micro computers, verification of operation and take measures against bugs in ECU using HILS

**Offering real plant models**
- Create high fidelity plant models with properties extremely close to the actual machine.
- Can conceal proprietary information such as machine geometry.
- RT models can be easily transmitted between multiple groups.

**How to create J MAG-RT models**
- J MAG’s finite element method (FEM) analysis feature allows the model creation even without an actual machine.
- Also possible from actual measurement values of the motor.
- Plant models can also be obtained from the J MAG-RT motor model library.

**Share models between system and plant designers**
- Create high fidelity plant models with properties extremely close to an actual machine and that can account for magnetic saturations or higher harmonics.

**Supported Models**
- Three-phase PM Synchronous Motors
- Three-phase induction motors
- Linear Solenoid
- Switched reluctance motors (3-5 phase)
- Two-phase Stepping Motor
- Three-phase permanent magnet linear motors

**Supported system**
- SILS/MILS
- MATLAB/Simulink
- PSIM
- LabVIEW
- GT-SUIT
- MapleSim (preliminary)
- SABER (preliminary)
- HILS
- OPAL-RT
- DSP Technology
- dSPACE
- National Instruments

General-purpose Applications Created in C++
- For more information, see the J MAG-RT System Requirements on the J MAG Website.

**Multi-domain Evaluation**

Comprehensive device design requires more than just electromagnetic analysis. A complete design must also examine factors such as vibration and thermal response. In order to achieve this, it is critical to work effectively in multiple analysis domains. We focus not only on an integrated environment for multiphysics, but also on linking to a variety of 3rd party software packages. This allows us to easily integrate into a customers’ analysis environment, and allows users to work with their desired analysis software.

- **Coupling with LMS Virtual.Lab**
  Possible to easily map structural analysis models and electromagnetic field analysis models. Because it is possible to export electromagnetic force distribution to the structural analysis model, it is now possible to realize high fidelity simulations.

- **Linking to Abaqus**
  Analyses can now be run to determine the large deformation of structures caused by stress and heat over time.

- **Multi-Purpose File Export Tool**
  The interfaces allows required information for structural analysis and heat analysis to be extracted from J MAG’s analysis data.

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RT J MAG-RT Viewer
Visualize machine parameters such as inductance and torque versus speed.
<table>
<thead>
<tr>
<th>Module</th>
<th>Analysis</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solver</td>
<td>ST (Magnetostatic 2D/3D) Can be applied when magnetomotive forces such as current and position of the object are not dependent on time. Linear or nonlinear material can be handled.</td>
<td>magnetic flux, magnetic field, magnetization, leakage flux, current, loss, magnetic force, Lorentz stored energy, permance</td>
</tr>
<tr>
<td>TR (Transient magnetic 3D) 3D analysis can be run when magnetomotive forces such as current and position of the object are dependent on time. Also, the nonlinear characteristics of the material can be handled accurately. Rotation motions or translation motions can also be handled.</td>
<td>magnetic flux, magnetic field, magnetization, leakage flux, current, loss, force, stored energy, permance, voltage, eddy current, displacement, speed</td>
<td></td>
</tr>
<tr>
<td>FQ (Time harmonic magnetic 2D/3D) Magnetic field analysis can be run when magnetomotive forces such as current change periodically. It is assumed that the material properties are linear, but by applying nonlinear data it is possible to run analysis that accounts for approximate nonlinearity analysis and hysteresis loop.</td>
<td>magnetic flux, magnetic field, magnetization, leakage flux, current, loss, force, stored energy, voltage, eddy current, electric field</td>
<td></td>
</tr>
<tr>
<td>DP (Transient magnetic 2D/Ax) A 2D analysis can be run when magnetomotive forces such as current and position of the object are dependent on time. When using a coupled solution between FEM and BEM, mesh divisions for the surrounding space is not required. Materials and motions can be handled in the same way as a 3D analysis.</td>
<td>magnetic flux, magnetic field, magnetization, leakage flux, current, loss, force, stored energy, permance, voltage, eddy current, displacement, speed</td>
<td></td>
</tr>
<tr>
<td>HT (Steady/Transient Thermal 3D) A thermal conduction analysis in a steady state and transient state is possible. This module is specially designed to be coupled with other magnetic field analysis modules, so it is easy to run coupled analysis inputting eddy current losses obtained from magnetic field analysis.</td>
<td>temperature, heat flux</td>
<td></td>
</tr>
<tr>
<td>EL (Electrostatic and time harmonic electric 3D) Runs a static electric field analysis/current distribution analysis of conductors and dielectric materials.</td>
<td>electric field, charge distribution, current distribution, electric force, loss</td>
<td></td>
</tr>
<tr>
<td>DS (Static/Dynamic Structural 2D/3D) Other than eigenvalue analysis of structures, it is possible to obtain static load and displacement and stress at times of steady vibration. In addition, it is possible to take into account electromagnetic force obtained from magnetic field analysis and temperature obtained from thermal analysis as load.</td>
<td>stress, displacement, acceleration, sound pressure</td>
<td></td>
</tr>
<tr>
<td>Tool</td>
<td>LS (Iron loss calculation) Calculates hysteresis loss and Joule loss for laminated steels and soft magnetic composite materials after static/dynamic magnetic field simulation. User defined loss characteristics data or data from the built-in material database may be used.</td>
<td>hysteresis loss, Joule loss</td>
</tr>
<tr>
<td>CB (Magnetic field calculation) Using data on magnetization vectors, current density and electric charge included in the results of magnetic field analysis or electric field analysis, this is a tool for calculating magnetic flux distribution or electric field in the specified locations (in the air) using an integral approach.</td>
<td>magnetic flux, electric field</td>
<td></td>
</tr>
<tr>
<td>RT (Generation of the behavior model for use in a circuit simulator) This is a tool that runs a magnetic field analysis, and outputs a motor model dedicated for circuit control simulations.</td>
<td>behavior model, inductance map</td>
<td></td>
</tr>
<tr>
<td>Pi (Burbar inductance calculation) In order to accurately calculate the conductor's inductance, the conductor is divided into several parts, and partial inductance of each part and between the parts is calculated.</td>
<td>inductance (total/partial)</td>
<td></td>
</tr>
<tr>
<td>PA2 (Parallel Accelerator 2 (DualCore, 2CPU-SMP) One License per parallel processing task) Supports distributed calculation function and parallel solvers (SMP/OMP). Using multiple machine resources, it is possible to obtain solutions in a shorter time. J MAG-Designer officially supports GPUs from Ver. 12.0.</td>
<td>winding inductance, winding DC resistance</td>
<td></td>
</tr>
<tr>
<td>TS (Transformer Templates Evaluate Winding Loss) Runs an electromagnetic field analysis specializing in transformers, reactors and inductance. A 3D analysis model can be created by selecting a core, bobbin and coil. Rapidly analyzes winding losses including litz wire accounting for skin and proximity effects.</td>
<td>efficiency/iron loss/copper loss maps, torque-speed curve (N-T), d/q current-speed curve (N-id/q), current amplitude-speed curve (N-lam), Ld/Lq map</td>
<td></td>
</tr>
<tr>
<td>Efficiency Map (Motor efficiency map calculation function) Applies user specified current vector controls and draws efficiency maps or torque-speed curves that consider current and voltage limits.</td>
<td>efficiency/iron loss/copper loss maps, torque-speed curve (N-T), d/q current-speed curve (N-id/q), current amplitude-speed curve (N-lam), Ld/Lq map</td>
<td></td>
</tr>
<tr>
<td>JMAG-Express (Motor basic characteristics calculation function) This is a tool for calculating a motor's basic characteristics. Everything from analysis model creation to results output for cogging torque analysis, efficiency map calculation, magnet eddy current loss analysis, and others can be accomplished by selecting geometries, materials, and windings.</td>
<td>Please see page 7.</td>
<td></td>
</tr>
</tbody>
</table>
**J MAG Application Catalog**

J MAG is electromagnetic field analysis software suited for a variety of applications including motors. The Application Notes that are provided with the model data available in this catalog are an instrumental teaching aid for users inexperienced in analysis software, or for experienced users that want to explore new fields using simulations.

### IPM motor/SPM motor
- Analysis of eddy currents using the gap flux boundary
- Analysis of iron loss considering the stress injection
- Analysis of surface magnetic flux density
- Centrifugal force analysis
- Centrifugal force subversion analysis
- Cogging torque analysis
- Cogging torque analysis with a skewed stator
- Demagnetization analysis
- Eccentricity analysis
- Efficiency analysis
- Efficiency map
- Inductance analysis
- Iron loss analysis
- Iron loss analysis including the effect of shrivking fitting
- Iron loss analysis accounting for pwn
- Iron loss analysis with overhanging magnet
- Magnetization analysis
- Magnetization analysis with a skewed magnet
- Press fit analysis
- Segregation analysis of torque components
- Sound pressure analysis
- Stray capacitance analysis
- Thermal analysis
- Thermal demagnetization analysis
- Vector control analysis

### Induction motor
- Iron loss analysis
- Line start analysis
- Load analysis
- Speed vs. Torque analysis
- Starting performance analysis
- Torque analysis
- Torque characteristics analysis

### Linear motor
- Analysis of the cogging of a permanent magnet
- Cogging analysis of a moving coil linear motor
- Thrust force analysis of a linear induction motor
- Thrust force analysis of a coreless linear motor
- Thrust force analysis of a linear induction motor
- Starting thrust force analysis
- Speed control analysis

### SR motor
- Drive simulation of an sr motor using a Control simulator and the J MAG-RT system
- Torque ripple analysis
- Vibration analysis

### Axial gap motor
- Load analysis

### Synchronous reluctance motor
- Load analysis

### Stepper motor
- Analysis of a hybrid stepper motor
- Characteristic analysis considering the magnetization
- Detent torque analysis
- Pull in/pull out torque analysis
- Stiffness torque analysis

### Speaker/Voice coil motor
- Analysis of static thrust of a voice coil motor
- Sound pressure analysis of a loudspeaker

### Brush motor/Universal motor
- Analysis of a permanent magnet brush motor
- Analysis of a slot motor: 2 brushes, 6 poles, and 19 slots
- Analysis of characteristics of a universal motor
- Iron loss analysis of a brush motor
- Starting performance analysis of a universal motor

### Spindle motor
- Load analysis

### Coreless motor
- Torque analysis

### Bearing
- Stray capacitance analysis of a motor

### Shaft motor
- Thrust force analysis

### Basic geometry
- Thermal conductivity analysis of basic geometry
- Structural analysis of a cantilever

### Busbar
- Inductance analysis
- Thermal analysis

### Cable
- Impedance-frequency characteristic analysis

### Condenser
- Capacitance analysis

### Electromagnetic brake
- Breaking torque analysis

### Electromagnetic forming
- Analysis of electromagnetic forming

### Electromagnetic relay
- Operating time analysis
- Operating time analysis of accounting for eddy currents

### Generator
- Output analysis of a salient pole synchronous Generator
- Analysis of a claw pole alternator

### Heater
- Thermal analysis

### Inductive power supply system
- Transmission characteristic analysis
- Transmission characteristic analysis with opposing cores

### Induction heating
- High-frequency induction heating analysis of a constant velocity joint
- High-frequency induction heating analysis of a drive shaft
- High-frequency induction heating analysis of a printer roller
- High-frequency induction heating analysis of a steel sheet
- High-frequency induction heating analysis of a steel wire
- High-frequency induction heating analysis of a gear
- Magnetic shielding analysis of an induction furnace
- Surface heating analysis of an iron sheet

### Linear solenoid/Linear actuator
- Attractive force analysis
- Operating time analysis
- Response analysis

### Magnet
- Analysis of an effect of magnetic field orientation on magnetization
- Analysis of attractive force between steel sheets and a magnet

### Magnetic head
- Surface heating analysis of an iron sheet

### Magnetic shield
- Magnetic shielding analysis

### Piezoelectric actuator
- Stroke analysis

### Resistance Heating
- Resistance heating analysis

### RFID
- Inductance analysis

### Sensor
- Magnetic field analysis of a magnetic sensor
- Magnetic field analysis of a speed sensor

### Superconductor
- AC loss analysis

### Switching gear / Breaker
- Analysis of magnetic blowout force acting on the arc of a switching gear
- Electrodynamic repulsion force analysis of a switching gear

### Transformer/Reactor
- All-value analysis
- Analysis of a transformer
- Current distribution analysis
- Evaluation analysis
- Inductance analysis
- Iron loss analysis
- Leakage inductance analysis
- Loss analysis
- Sound pressure analysis
- Superimposed direct current characteristic analysis
- Thermal analysis
Analysis of the Eddy Current in the Magnet of an IPM Motor

Magnetization Analysis of an SPM Motor

Torque Analysis of a Three Phase Induction Motor Accounting for the Skew

Line Start Simulation of an Induction Machine Using a Control Simulator and the JMAG-RT System

High-frequency induction heating analysis of a test piece

Current Distribution Analysis of a Choke Coil

Magnetic Field Analysis of a Speed Sensor

Analysis of a Hybrid Stepper Motor

Sound Pressure Analysis of a Loudspeaker

Operating Time Analysis of an Injector by Evaluating the Reduction in Eddy Currents

Analysis of a Claw Pole Alternator

Vibration Analysis of an Outer Rotor Motor

Eddy current loss distribution in the magnet

Surface Magnetic Flux Density Waveform of the Magnet

Current density distribution (Z component)

Torque waveform

Temperature distribution

Current density distribution

Flux Density Distribution

Stiffness Torque with One-phase Excited

Sound Pressure Level Distribution

Current Density Distribution (with slits)

Eddy Current Density Distribution

Eigenmode deformation in the radial direction

There are over 140 more case examples available. See the JMAG Website for more details.

www.jmag-international.com/
Anyone can say they provide superior quality and functionality, but the JSOL Corporation and its partners recognize that everyone interested in J MAG deserves proof rather than conjecture. Therefore, we include a wealth of information on the J MAG Website accessible to anyone.

Application Catalog
The Application Catalog introduces hundreds of example simulations by application to give you an outstanding overview of the possibilities of J MAG. The detailed procedures and model data of the Application Notes are available after signing up for the 60-day free trial.

Video Tutorials
These visual tutorials are a quick and easy way to get to know the J MAG procedures and analyses. Each video is separated by application and offers step by step guidance from starting J MAG to evaluating the results.

J MAG Newsletter
This newsletter includes detailed interviews with users that describe each aspect of J MAG from implementation to utilization.

Paper Introduction
Allow us to introduce papers recommended by J MAG technicians.

J MAG Seminar Material, Users Conference Presentation Material
(for users only)
We are enclosing for your perusal material introducing the latest technology and case studies announced by users.

Technical FAQ (for users only)
Regarding using J MAG, we want even more people to know about common shared issues like operation and solutions. To offer these, we update the technical FAQ now and then.

Self Learning System (J MAG-SLS)
The self learning system provides a self learning environment with procedures, video tutorials, and the parameters necessary to create analysis models and run various simulations.

GET a Trial Version for Free

For more information about J MAG, visit http://www.jmag-international.com/

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