# Software for Electromagnetic Field Analysis
# JMAG-Studio

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**http://www.jri.co.jp/pro-eng/jmag/e/jmg/index.html**

## Outline

- **Introduction to JRI**
- **Capabilities & Features of JMAG**
- **Application examples**

# The Japan Research Institute

| | |
|---|---|
| **Established** | **1969** |
| **Capital** | **100 billion JPY** |
| **Employees** | **2,542 (2002)** |
| **Headquarters** | **Tokyo & Osaka** |

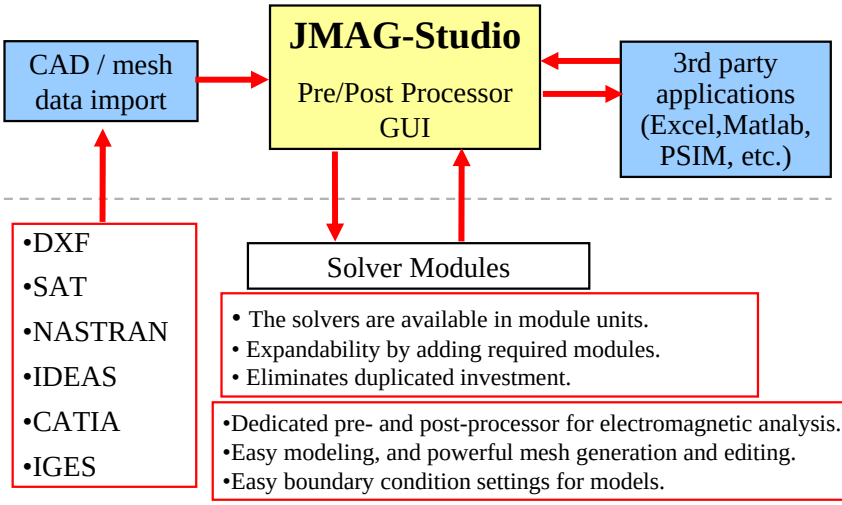
*From Dreams to Reality through "Knowledge Engineering"*

# Engineering Technology Division

- **Structural Engineering Group**
  - **Car crash, Metal forming and stamping, Dropping…**
  - **LS-Dyna, JVision, J-Stamp**
- **Electromagnetic Engineering Group**
  - **Motors, actuators, antennas, waveguides,…**
  - **JMAG**

***JMAG is an integrated electromagnetics solutions package***

## JMAG Product Structure



## Supported Platforms

**JMAG-Studio (GUI)**

- **Windows 2000, XP**

**Solver Modules**

- **Windows 2000, XP**
- **UNIX (IBM, SGI, HP, Sun)**

## Analysis Types

- **Magnetics (Static, Transient, Harmonic) including super-conductors**
- **Electrostatics, charge distribution**
- **Electromagnetic wave, including optics**
- **Heat conduction**
- **Structures**
- **Coupled analysis**

## Applications

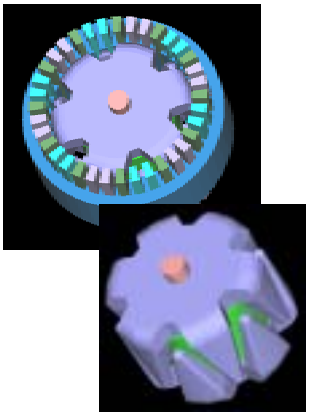
- **Electric motors, Generators, Transformers, Solenoid valves, Actuators, Induction Heating, Magnetic Recording Heads, Super Conductors, Antennas, Waveguides, EM Shields, NDT devices, Magnetization Processes, Printing ...**

## Major Clients

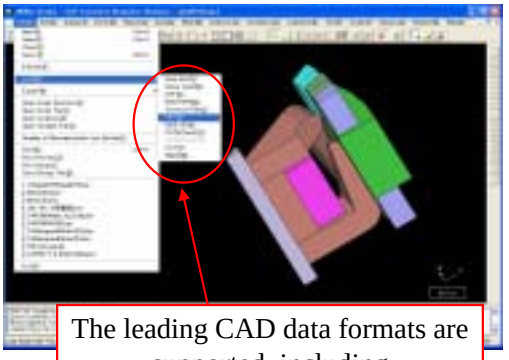
- **Automobile Manufacturers & Suppliers**
  - **Toyota, Honda, Nissan, Denso, Zexel...**
- **Electric & Electronics**
  - **Mitsubishi, Matsushita, Toshiba, Hitachi, Sharp, Sanyo, Victor, Fuji, Fujitsu, NEC...**
- **Others**
  - **Canon, TEPCO, Sumitomo...**

***JMAG-Studio's preprocessor fully supports electromagnetic analysis and allows the easy creation of models***

## Easy to use GUI
## -Importing CAD data-



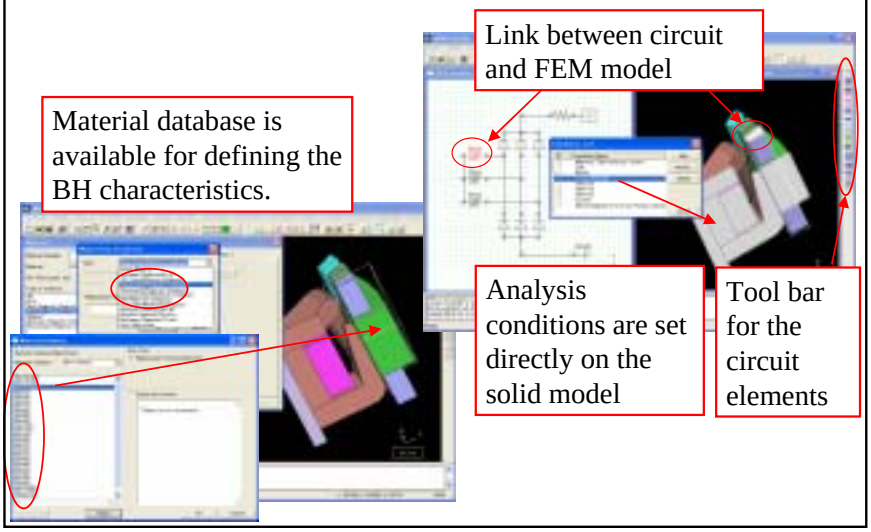
**Claw pole alternator**



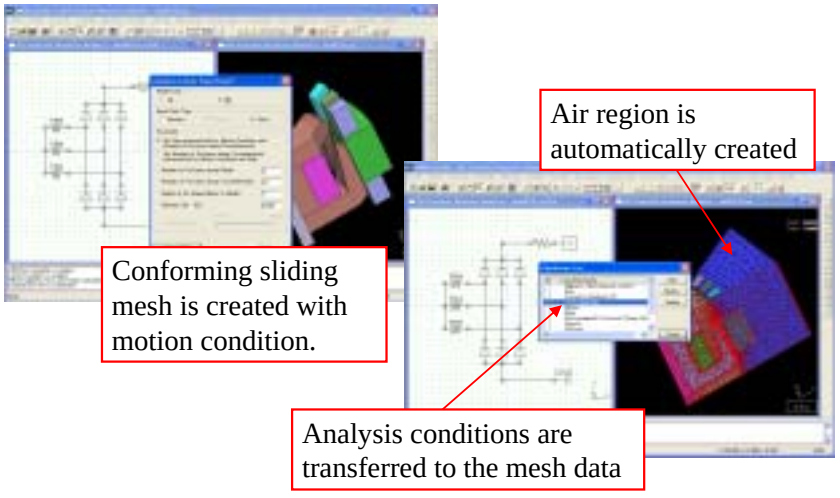
The leading CAD data formats are supported, including

SAT,DXF,CATIA,IGES,IDEAS

## Easy to use GUI
## -Setting analysis conditions-

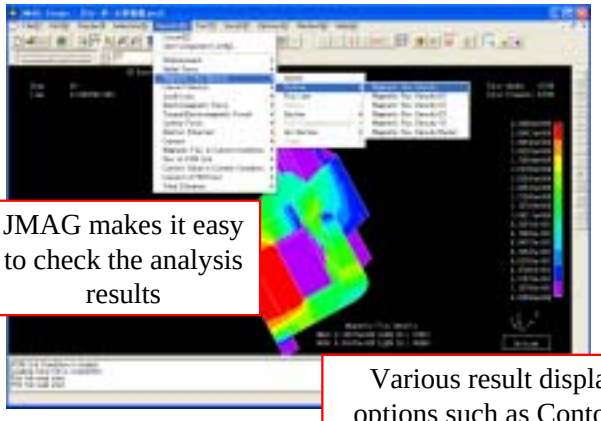



## Easy to use GUI
## -Powerful Mesh Generator-

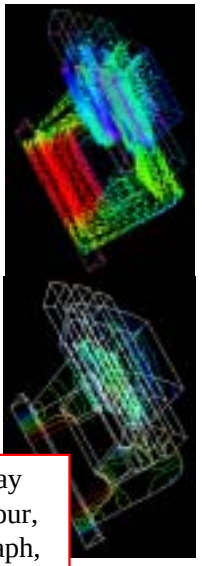


***JMAG-Studio's integrated post-processor is specifically designed for displaying the results of electromagnetic simulations.***

## Easy to use GUI
## -Displaying Results-

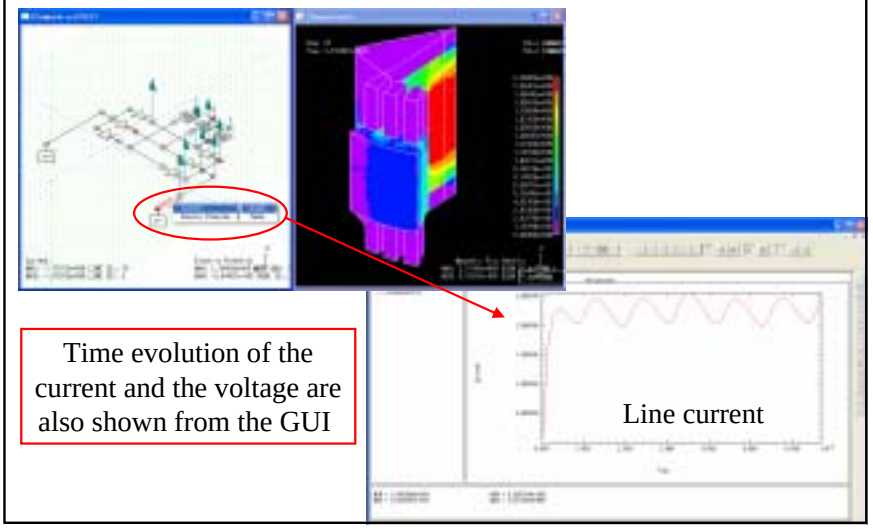


JMAG makes it easy to check the analysis results



Various result display options such as Contour, Vector, Flux line, Graph, Table, Animation…

## Easy to use GUI
## -Displaying Results-




Time evolution of the current and the voltage are also shown from the GUI

## Features

- **Powerful coupled analysis feature.**
- **Capability for motion problems.**
- **High speed with memory saving features.**
- **Rich material database provided by material manufactures.**

## Coupled analysis

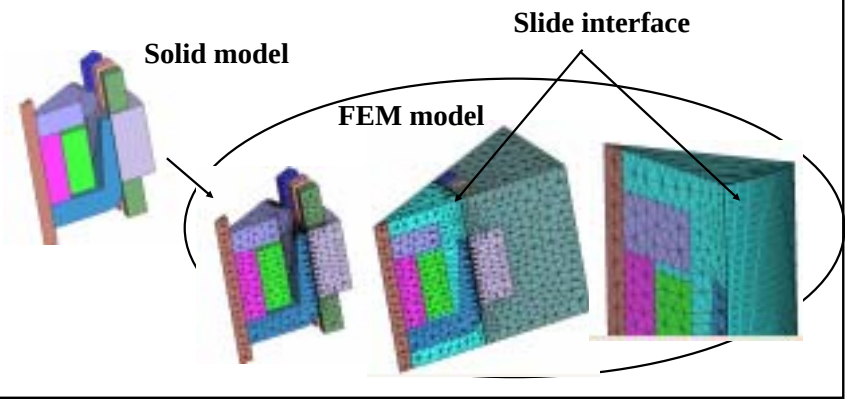
- **JMAG can easily couple electromagnetic simulation with the following:**
  - **Structure**
  - **Thermal**
  - **Mechanical motion**
  - **Electric circuit**
  - **Control (MATLAB/Simulink, PSIM, etc)**

## Motion problem

- **Mesh generator tuned for rotating machine**
- **Patch meshing technique**
- **Adaptive mesh**

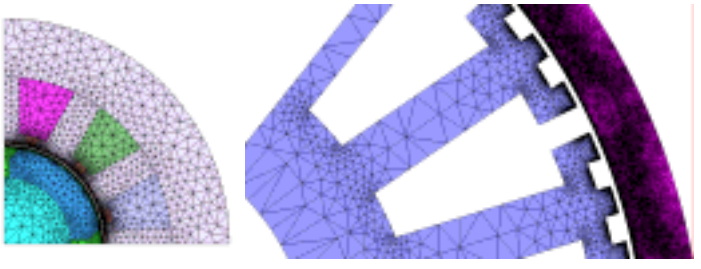
# Mesh Generator for rotating machines

- **Conforming slide interfaces are generated by the automatic mesh generator for solid models.**



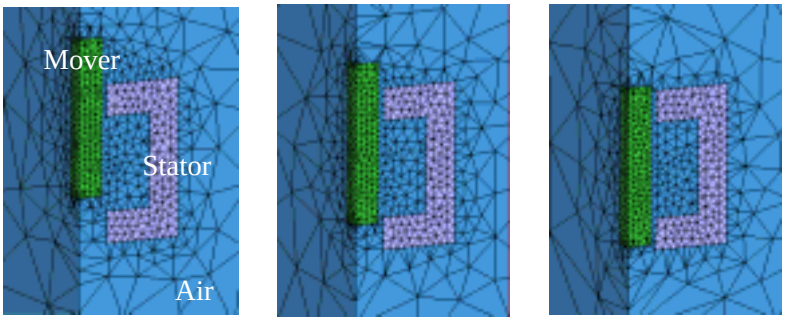

# Mesh Generator for rotating machines

- **The automatic mesh generator creates a balanced mesh reflecting geometrical symmetry.**
- **This feature enables JMAG to accurately evaluate parameters, such as cogging torque which are sensitive to mesh symmetry.**



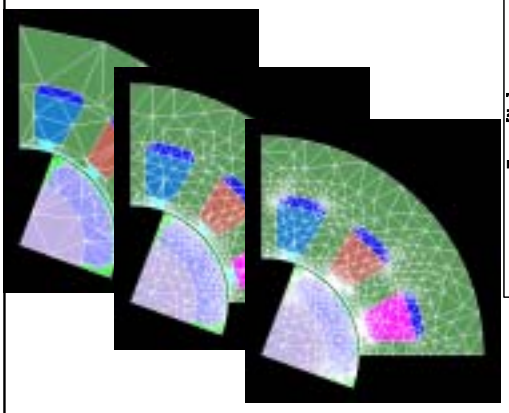
# Patch meshing

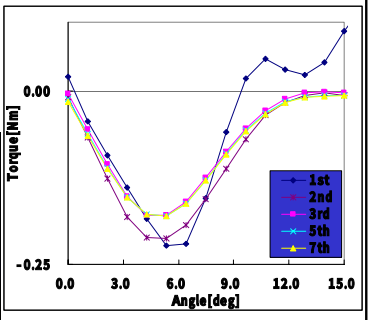
- **“Patch meshing” allows arbitrary motion.**
- **The technique generates a high quality mesh at each time step.**




# Adaptive meshing

- **JMAG’s adaptive meshing can be used for motion problems.**






***Adaptive meshing enables beginners to achieve good results.***

## High speed and low memory

- **JMAG combines the advantages of edge elements and an optimized ICCG solver.**
- **Robust algorithm for coupled analysis with electric circuits.**
- **For motion problems, conforming slide interface and patch meshing technique ensure stable convergence.**

## Material Data base

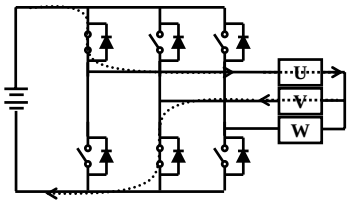
- **A material database for electrical steels and magnets is provided with data from the major material manufactures.**
- **Users can set material properties by choosing item names from the database which has over 300 items.**
- **Electrical Steel:**
  - **Nippon Steel, JFE, Höganäs AB**
- **Magnet:**
  - **SSMC, Hitachi Metal, Shin-Etsu, TDK**

# Application examples

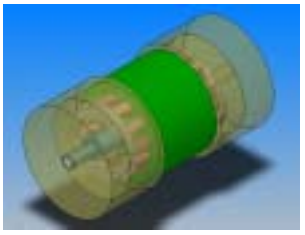
- **Motors**
- **Solenoid valve**
- **Eddy current brake**
- **Super conducting cable**
- **Induction heating**
- **Magnetic head**

# PM motor

- **Users can *easily* obtain characteristics and evaluate performance of PM( Permanent Magnet) motor with JMAG.**

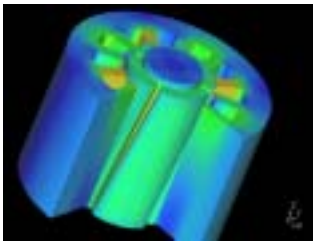


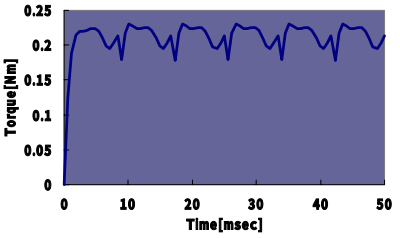

**Drive circuit**

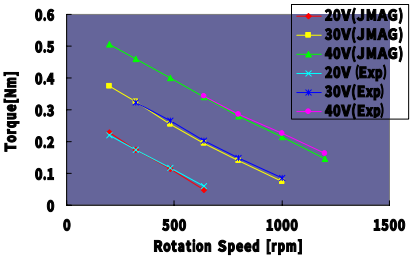


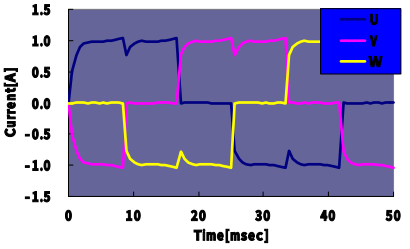
**PM motor**

# PM motor



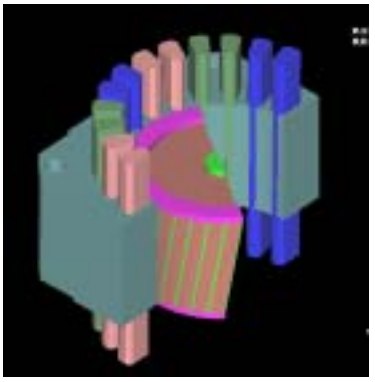


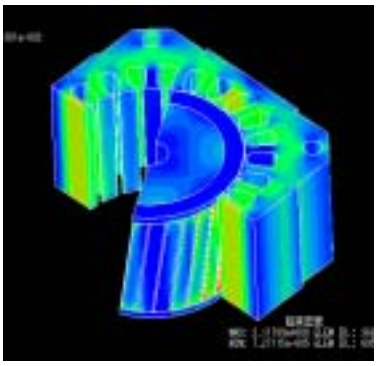




# Induction motor

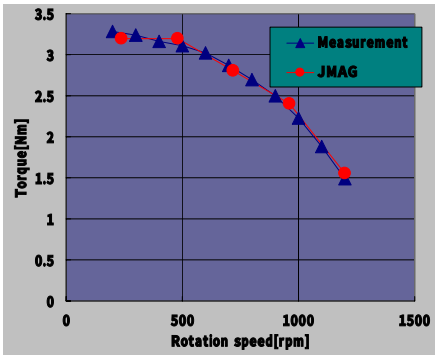
- **Induction motor analysis requires accurate eddy current calculation and meshing capability for complicated geometry. JMAG fulfills those requirements.**



# Induction motor



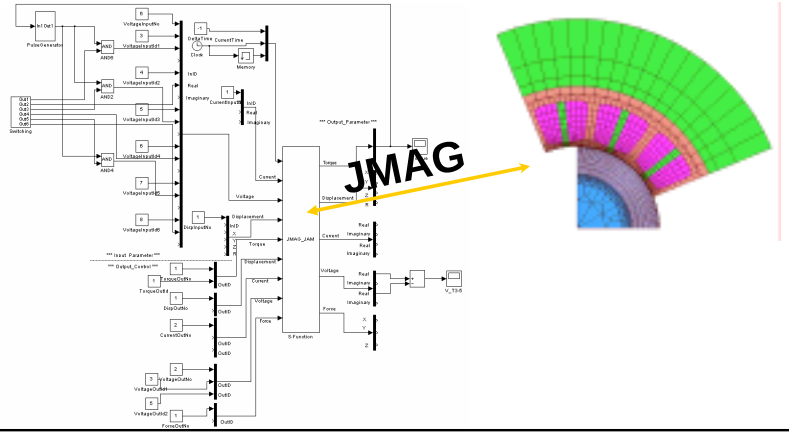
Magnetic flux density



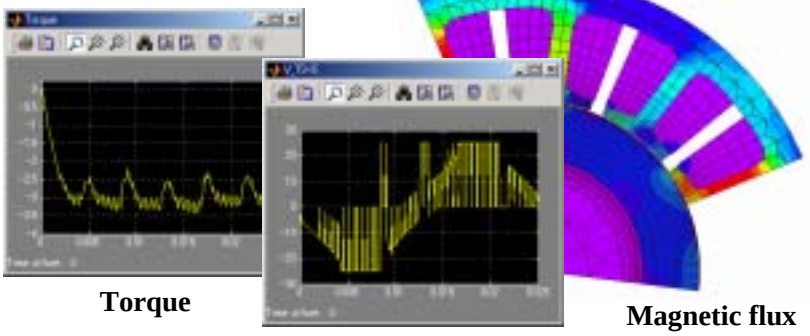

Torque versus Speed

# JMAG-Matlab/Simulink coupled analysis

- **Coupling JMAG and Matlab/Simulink solves complex control circuitry problems such as PWM.**



# JMAG-Matlab/Simulink coupled analysis



Torque

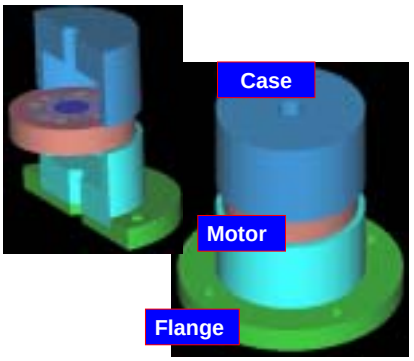
Line voltage

Magnetic flux density

**Results show torque, line voltage and magnetic flux density of PM motor under PWM control system.**

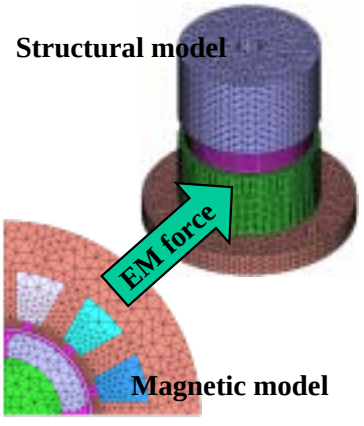
# Vibratoin analysis

- **JMAG has the capability of structural analysis which takes account of the EM force.**




**Motor with case and flange**

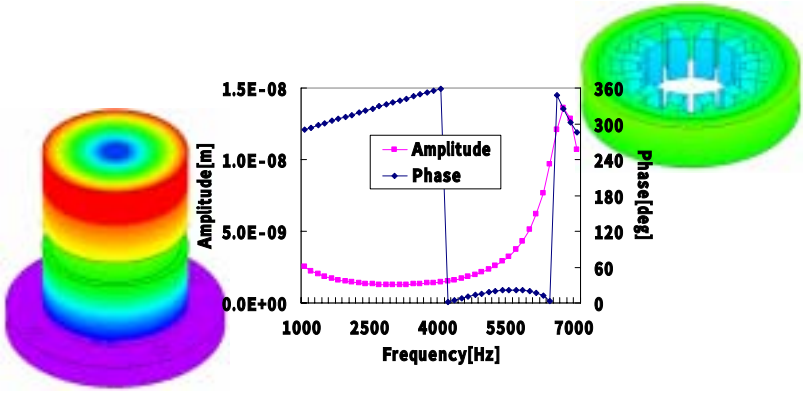
**Structural model**




**Magnetic model**

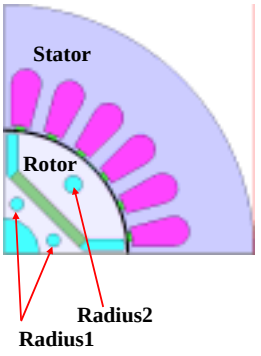
# Vibratoin analysis

- **JMAG can determine the frequency response of the displacement caused by the motor drive.**



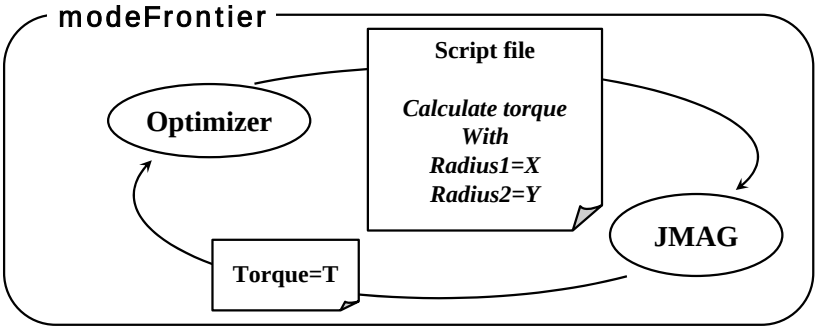

# Optimization

- **Geometry optimization is performed for a PM motor to design the radii of holes in the rotor.**
- **Lager radius leads lower weight but torque goes down.**
- **The goal is “higher torque and lower weight”.**
- **The problem is solved by modeFrontier with JMAG.**



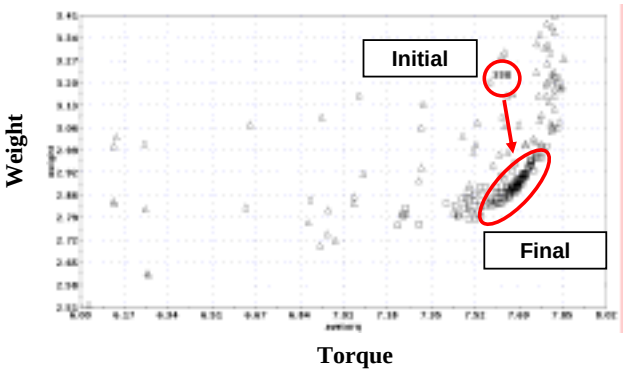
# Optimization

- **JMAG's script file can control all JMAG functions in "batch mode" so that modeFrontier can control JMAG in its optimization process.**



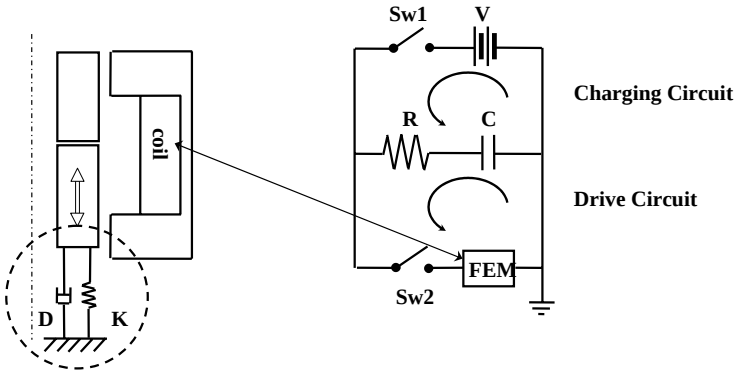

# Optimization

- **Keeping torque level, less weight is achieved by optimization using modeFrontier and JMAG.**



# Solenoid valve

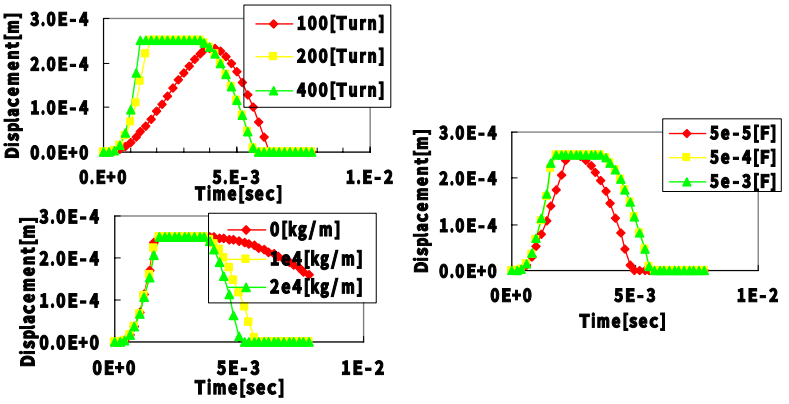
- **JMAG simulates response of solenoid valve by coupling EM with mechanical motion and circuit.**




**Magnetic and motion model** **Circuit model**

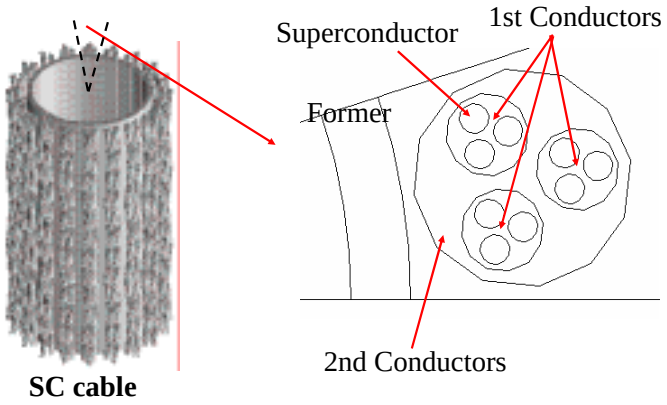
# Solenoid valve

- **JMAG results shows response dependency to number of turns, capacitance and spring constant.**



# Superconducting Cable

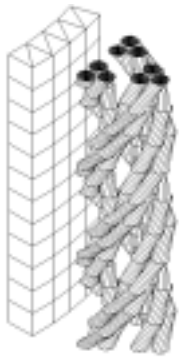
- **JMAG has special material models for Super conductors.**




**SC cable**

# Superconducting Cable

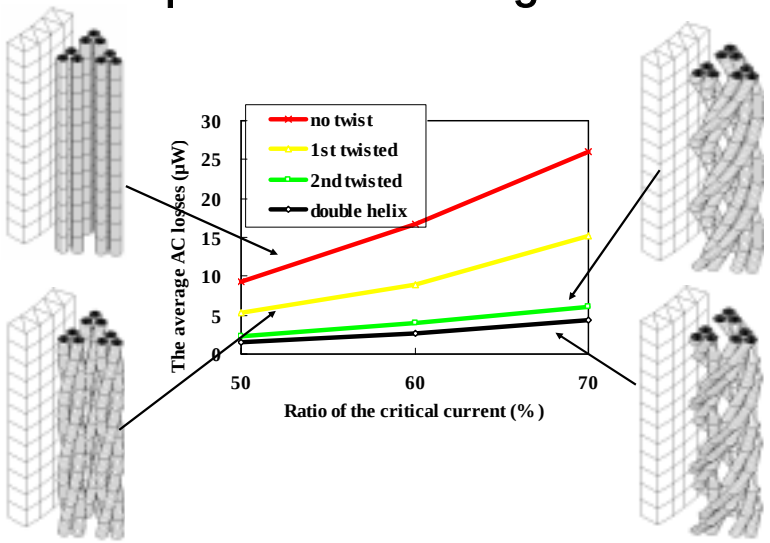
- **JMAG's mesh generator allows complicated twisting.**



Mesh for "Double Helix" twist

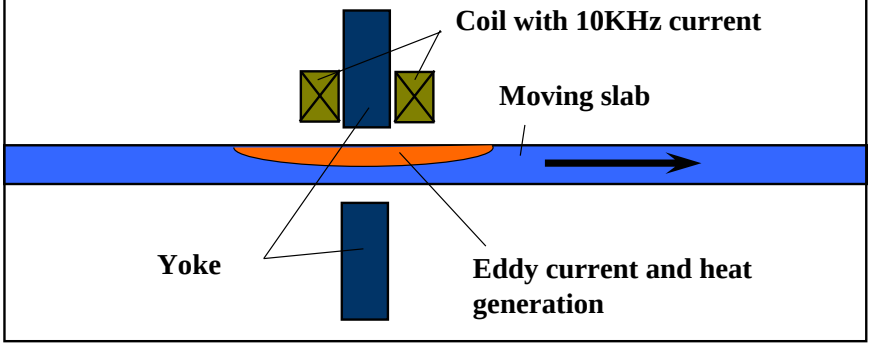
Result showing eddy current

# Superconducting Cable

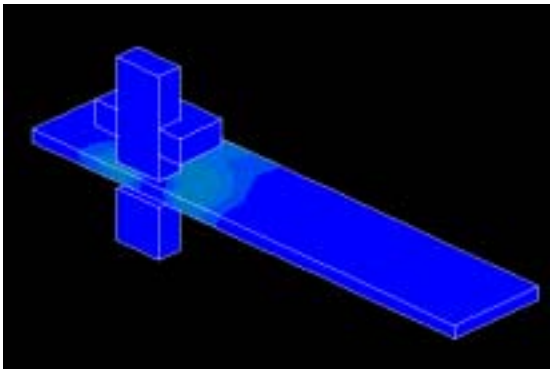



# Induction Heating System

- **Induction heating system used in metal making process to relax stress is simulated by JMAG taking into account of convection on the moving conductor.**



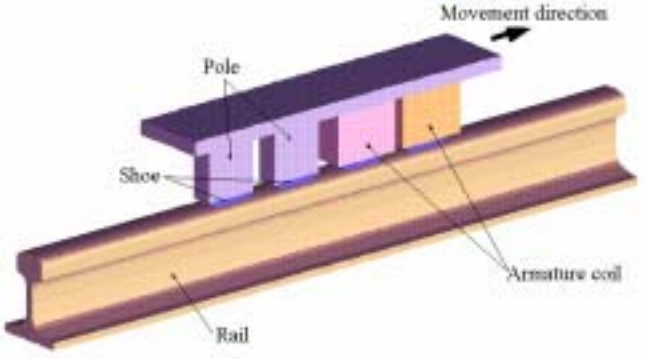
# Induction Heating System



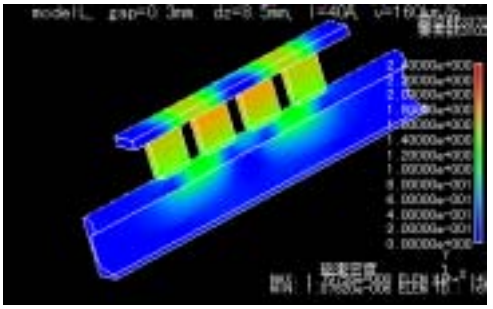
**Temperature distribution in the slab**

# Electromagnetic brake used in high speed train

- **Braking force is caused by interaction between the magnetic field produced by the coil and the eddy currents induced in the rail.**



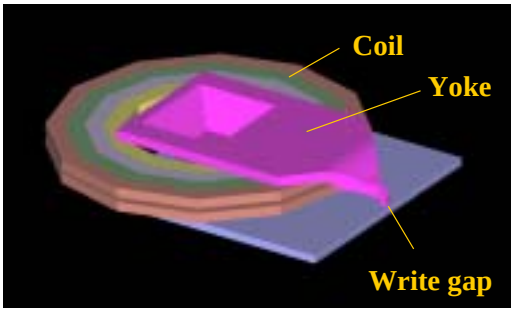
# Electromagnetic brake used in high speed train



**Time variation of the magnetic flux density showing how the magnetic flux is dragged by the motion of the brake shoe.**

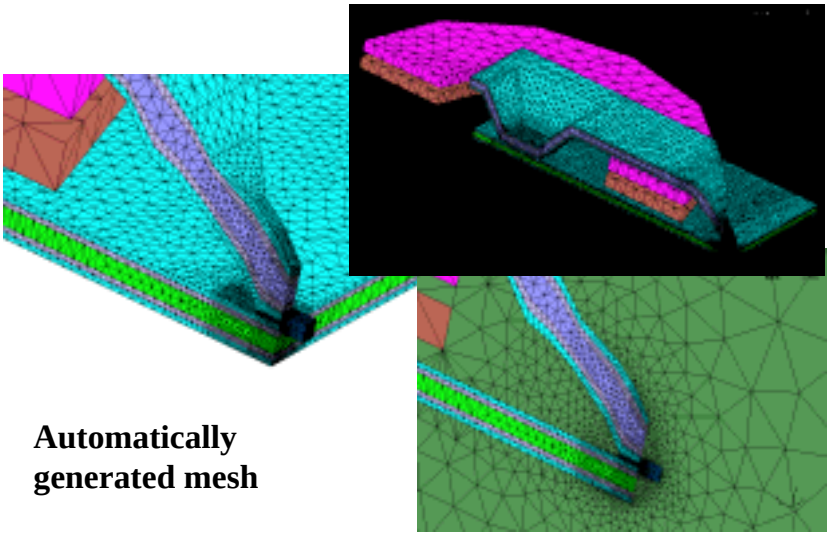
# Magnetic Recording Head

- **Magnetic recording head simulation requires a quality mesh for the narrow write gap and "skin depth" for eddy current.**



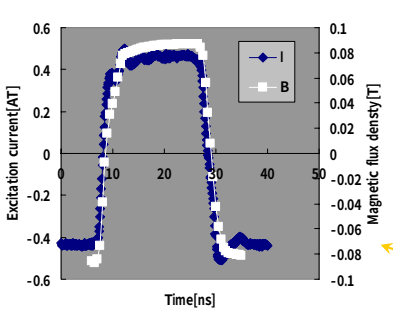

**Canonical problem of SRC* simulation working group (*Storage Research Consortium of Japan)**

# Magnetic Recording Head

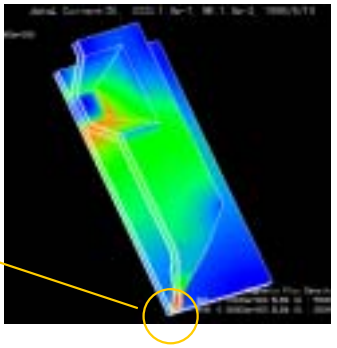


**Automatically generated mesh**

# Magnetic Recording Head




Response of magnetic flux density



Magnetic flux density

# Summary

**JMAG-Studio provides an integrated simulation package for a wide variety of electromagnetic problems.**