The Future of JMAG-RT for Furthering Model Based Design

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Abstract :

"Model Based Design" which is furthering the development process of systems as a whole utilizing MATLAB/Simulink is becoming more widespread, but system development including motors is still not perfect. The challenge is converting models to highly accurate models or ID models that can be used in HILS/SILS. JMAG-RT provides motor models that take into account real motor characteristics through FEA. This presentation introduces JSOL's efforts to achieve highly accurate plant models.

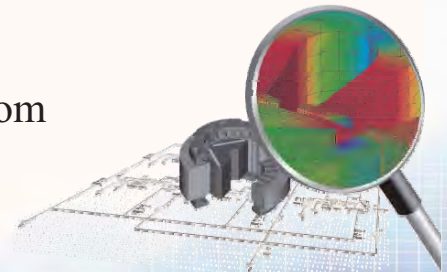Simulation Technology for Electromechanical Design

JMAG Users Conference 2010

Furthering Model Based Design
The Future of JMAG-RT

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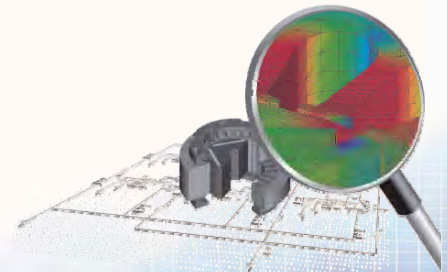 - Achieving Easier-to-Use Motor Models

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Overview of JMAG-RT
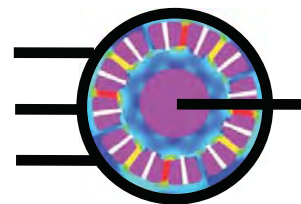
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Overview of JMAG-RT

- Extract characteristics from FEA models to 1D models
- Achieves highly accurate models that contain detailed characteristic information
- Operates at the same high speeds as conventional 1D models
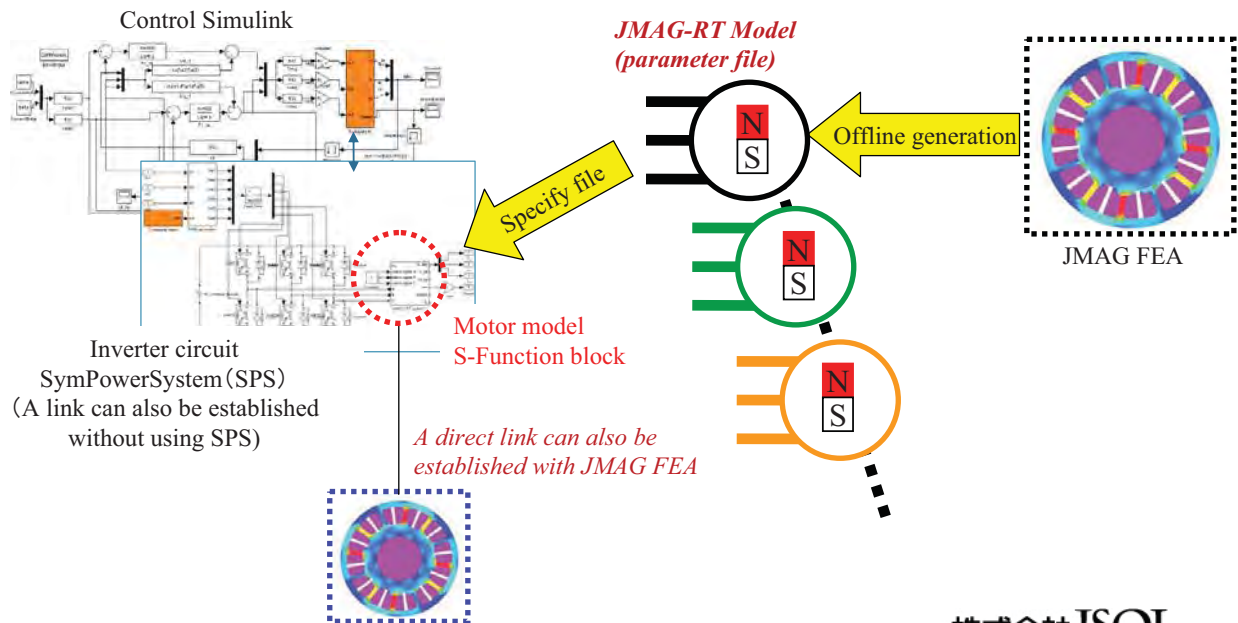- Using JMAG-RT models is free (no license required)

JMAG Model（3D）   **Extract**   **JMAG-RT Model（1D）**

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Linking JMAG-RT to Simulink

- Recognized as an S-Function block in Simulink
- Replace models by simply changing the parameter file

Control Simulink

JMAG-RT Model (parameter file)

Offline generation

JMAG FEA

Specify file

Motor model
S-Function block

Inverter circuit
SymPowerSystem（SPS）
（A link can also be established
without using SPS)

*A direct link can also be
established with JMAG FEA*

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Linking JMAG-RT to Simulink

	Method 1：JMAG (FEA)	Method 2：JMAG-RT	Simulink Embedded Models (for reference）
Model	Universal	PMSM, solenoids, stepper motors	PMSM, solenoids, stepper motors
Objective	Component design	Control design System evaluation	Control design System evaluation
Simulation Mode	FEA co-simulations	Equivalent circuit models (with lookup tables)	Equivalent circuit models
Simulink I/F	S-Function (provided by JSOL）	S-Function (provided by JSOL）	Built-in
SimPowerSystem	Compatible, but not required	Compatible, but not required	
JMAG I/F	Online	Offline	
Calculation time	Several minutes to several hours	Several seconds to several minutes	Several seconds to several minutes
Output	Electromagnetic field distribution current, voltage, force, torque	current, voltage, force, torque	current, voltage, force, torque

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Creating JMAG-RT Models

- JMAG-RT models are created using JMAG or JMAG-Express
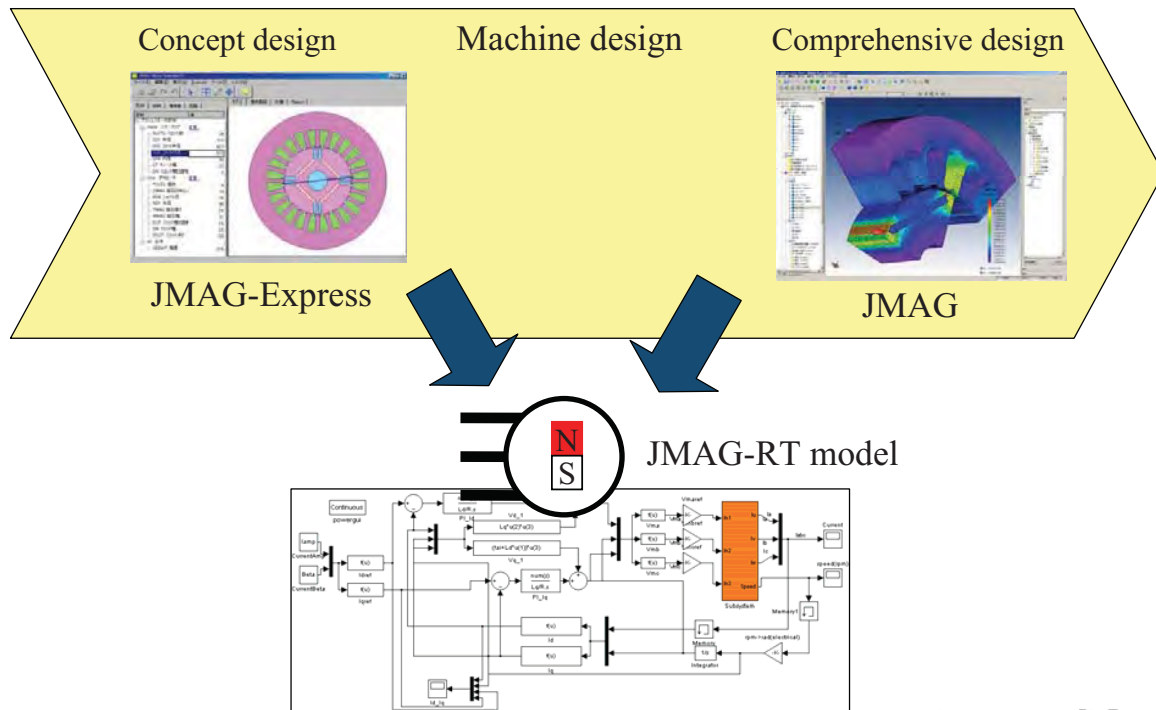
Concept design   Machine design   Comprehensive design

JMAG-Express   JMAG

JMAG-RT model

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Creating JMAG-RT Models（JMAG）

- Specify the degree of detail for the model in the JMAG-RT Library Manager, and then create the model

FEA model   **JMAG -RT**
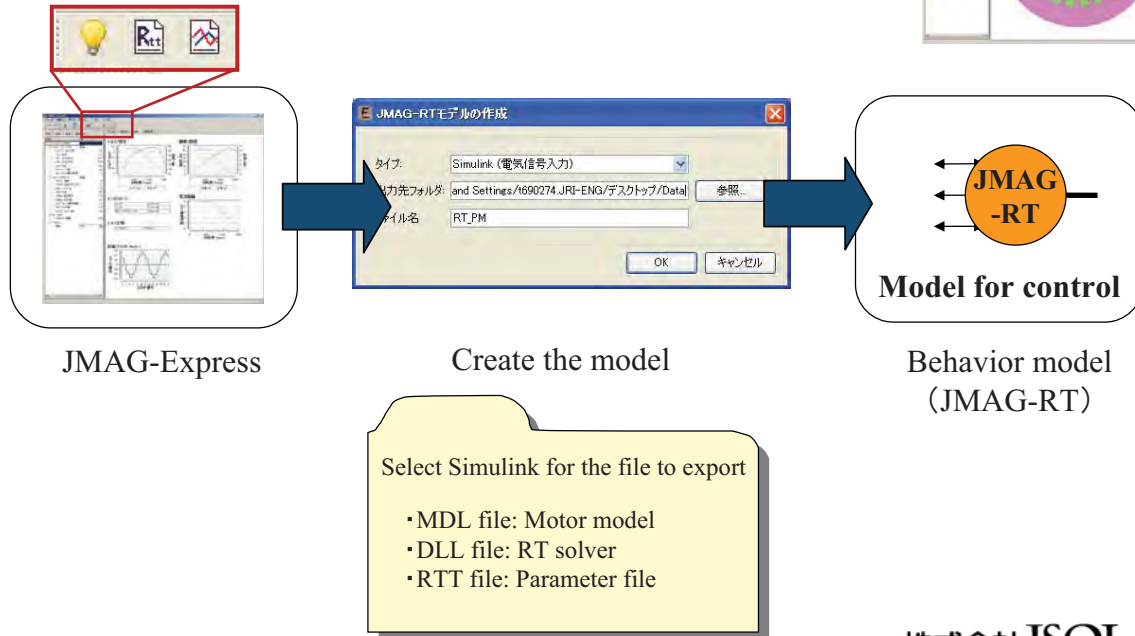
                                                  Model for control

FEA Model   JMAG-RT Library Manager   Behavior model

（JMAG）   (Run a magnetic field analysis to   （JMAG-RT）

                   create the JMAG-RT model)

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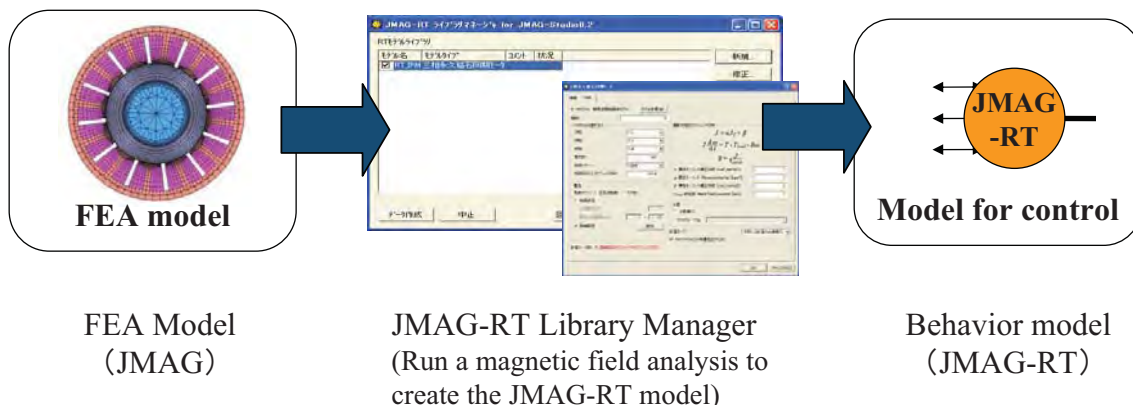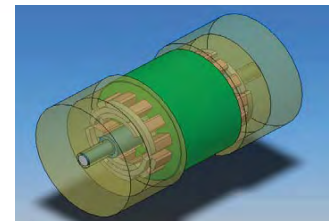
Creating JMAG-RT Models（JMAG-Express）

- Specify the parameters after starting JMAG-Express, and then click the [RTT] button

JMAG-Express   Create the model   Behavior model（JMAG-RT）

Select Simulink for the file to export

・MDL file: Motor model
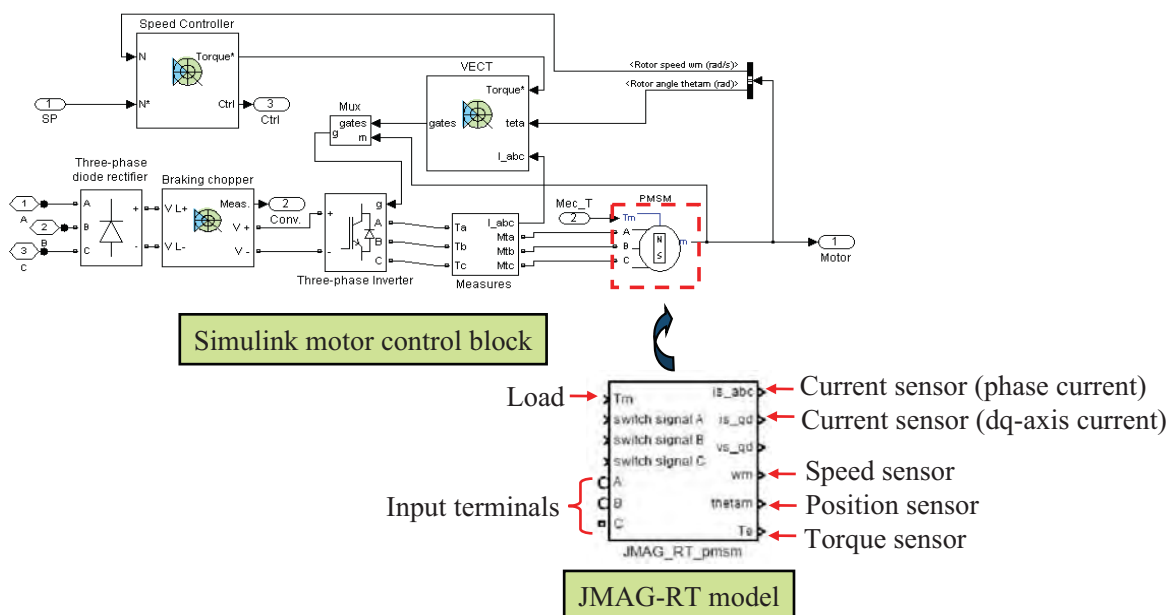・DLL file: RT solver
・RTT file: Parameter file

Using JMAG-RT Models

- The JMAG-RT model can be run seamlessly by replacing the existing motor block in MATLAB/Simulink and PSIM

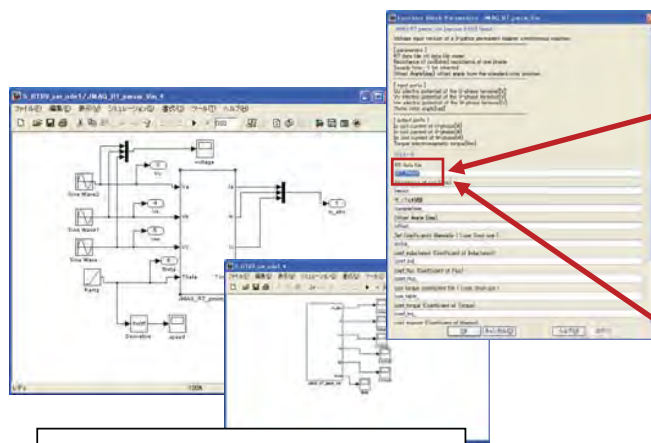*SimPowerSystem demo:AC6_example/PM Synchronous Motor Drive

Simulink motor control block

Load → Tm

Current sensor (phase current)
Current sensor (dq-axis current)
Input terminals
Speed sensor
Position sensor
Torque sensor

JMAG_RT_pmsm

JMAG-RT model

Using JMAG-RT Models

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- Replace the model by simply specifying the parameter file (RTT file)

Outside_stator_small.rtt
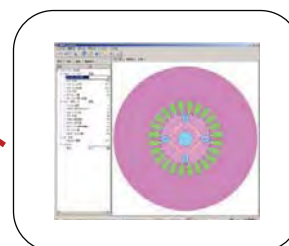
Outside_stator_large.rtt

Provided in JMAG-Express
MATLAB/Simulink sample circuit

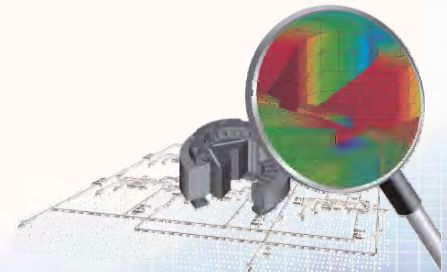   **http://www.jmag-international.com/**   株式会社 JSOL

Detail of Model

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- Select the degree of detail for the model

Model type	Magnetic Saturation	Spatial Harmonics	Time Cost	Model Size	Tool
LdLq	○	—	Small	Small	JMAG JMAG-Express
Simple Spatial Harmonics	○	○	Mid	Mid	JMAG
Spatial Harmonics	◎	◎	Large	Large	JMAG

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The Future of JMAG-RT

The JMAG-RT that JSOL Envisions

- JMAG is the foremost electromechanical design tool

- Models suited for a wide range of testing for electric, mechanical, and thermal characteristics are required considering the entire system

- JMAG-RT accurately simulates the electromechanical equipment designed by electromechanical engineers in 1D models.

- The simulation accuracy of the entire system is therefore increased by linking the control/circuit design, thermal design, and mechanical design in 1D models
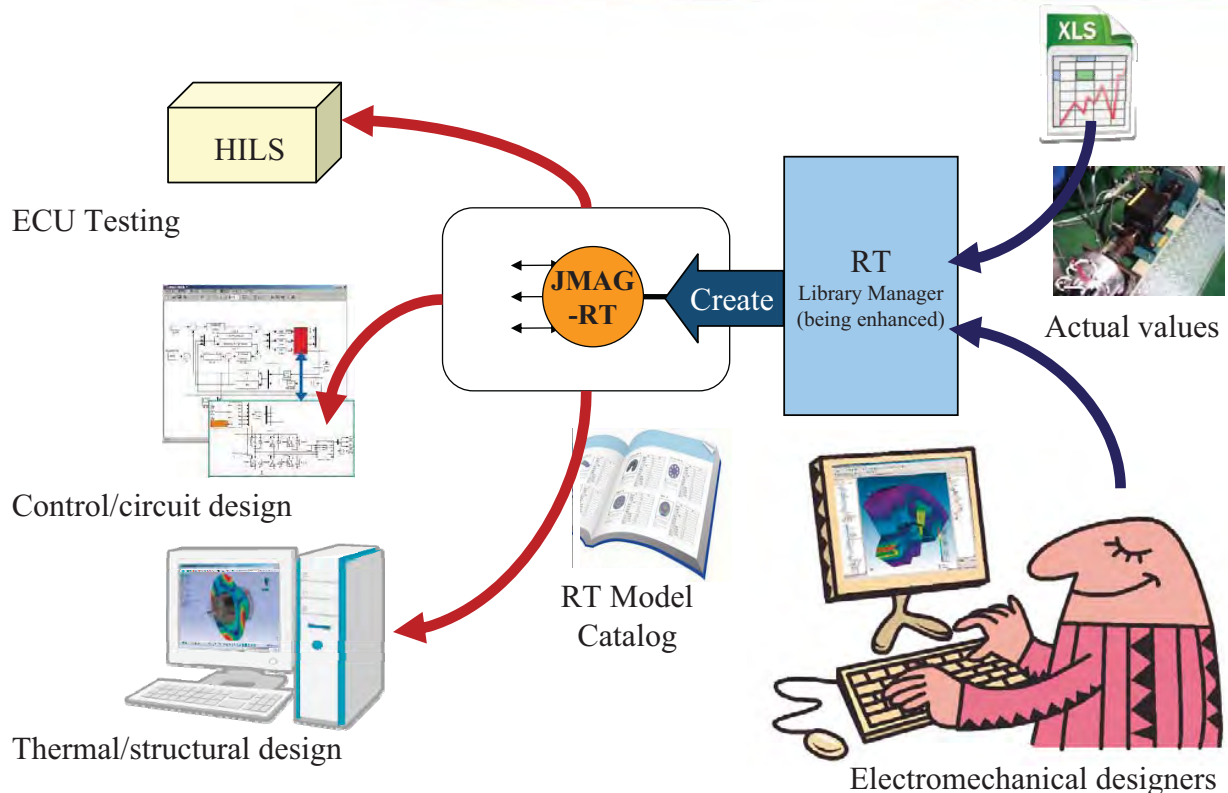
Challenges

- Who creates the RT motor models?
  - Motor designers

- Who uses the RT motor models?
  - Designers wanting to increase the accuracy of simulations for structural and thermal designs that account for electromagnetic force
  - System designers wanting to investigate the motor operation without an actual prototype

- How can I get RT motor models?
  - RT motor models are provided by the motor manufacturers
  - If the motor manufacture does not provide RT motor models:
    - Create the RT motor model using JMAG-Express
      （supports LdLq models/brushless motors）
    - Creating RT motor models from testing data will be possible in the future

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Demand and Distribution of JMAG-RT Motor Models

- HILS
- ECU Testing
- JMAG-RT
- Create
- RT Library Manager (being enhanced)
- Actual values
- Control/circuit design
- RT Model Catalog
- Thermal/structural design
- Electromechanical designers

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Providing More Accurate Motor Models will Become Possible

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Achieving More Accurate Plant Models

- Enhancing the RT Library Manager
  - Loss
  - Inductance
  - Heat
  - Simulate data other than the calculation results obtained in JMAG such as the measured values, experimental values, or theoretical values

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Achieving Easier-to-Use RT Motor Models

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Expanding the Application Range

- Phase permanent magnet synchronous motors
- 2-phase stepping motors
- Linear solenoids
- Permanent magnet linear motors
- Induction motors (planned)
- SR motors (planned)
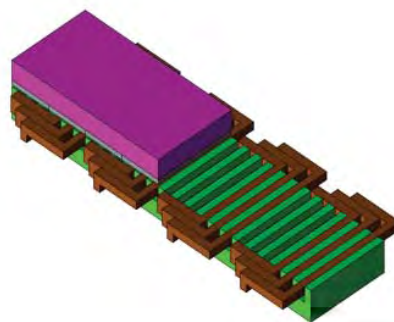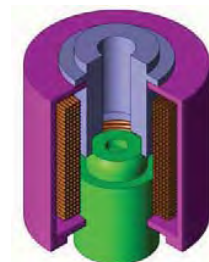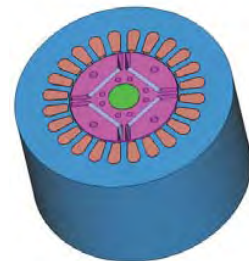
December 12, 2010
JMAG-Express only supports brushless motors

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Supported Systems

- ▪ SILS
  - − Mathworks (MATLAB/Simulink)
  - − Powersim (PSIM)
  - − National Instruments (LabVIEW)
- ▪ HILS
  - − OPAL-RT(RT-LAB)
  - − DSP Technology (RTSim)
  - − dSPACE
  - − National Instruments
- ▪ Universal applications written in C++

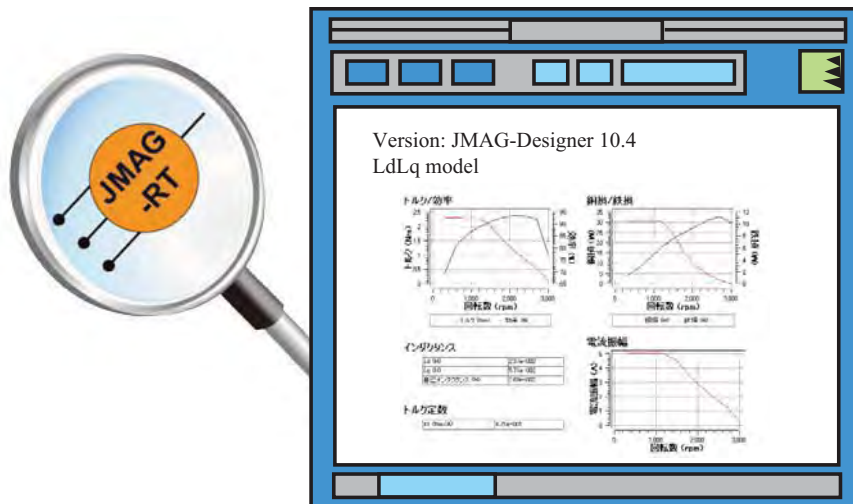   **http://www.jmag-international.com/**   株式会社 JSOL

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Achieving Easier-to-Use Plant Models

- ▪ RT-Viewer（tentative）is currently in development
  - - Display the degree of detail for RT models
  - - Display characteristics such as the N-T curve in a viewer
  - - Recalculate the above characteristics by specifying the drive conditions

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Conclusion

- JMAG-RT aims to achieve the specifications required to perform model based design.

- Necessary information, such as the motor characteristics, can be obtained with a specialized solver（distributed freely by JSOL）.

- JMAG-RT is beginning to be implemented into HILS and SILS

- JSOL is expanding the range of models that are supported, enhancing the RT Library Manager, and developing an RT-Viewer (tentative) to allow the distribution of more highly accurate plant models.

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