Maxwell and Simploter
Tips and Tricks

Ryan Magargle, PhD
Ansys, Inc.
Electromechanical Simulation

- ANSYS Icepack
- Simplorer System Design
- RMxprt Motor Design
- Q3D Parasitics
- Maxwell 2-D/3-D Electromagnetic Components
- ANSYS Mechanical Thermal/Stress
- PExprt Magnetics

Model order Reduction
Co-simulation
Field Solution
Model Generation
Maxwell Description

Solution Type

Post-Processing

Modeler Window

Project Manager

Properties Window

Message Manager

Progress Window
Outline

Maxwell
- Geometry
- Transient
- Post-Processing

Simplorer
- Transient Solver
- Post-Processing
- Advanced Analysis
Maxwell Geometry Interface

**Topic**

- Remove geometry commands in any order to reduce the need for redrawing geometry
Maxwell Geometry Interface

Example

• Create motor coils for symmetry, then change mind and undo symmetry
Maxwell Geometry Interface

Topic
• Increase geometry visibility with split planes
Maxwell Geometry Interface

Steps

1. Click Draw Clip Plane
2. Click Add-> Specify Center, Normal
Maxwell Geometry Interface

Steps

• Grab and drag to change clip plane view
Outline

Maxwell
  – Geometry
  – *Transient*
  – Post-Processing

Simpler
  – Transient Solver
  – Post-Processing
  – Advanced Analysis
Maxwell Transient Solver

Topic
• Multiple objects with independent motion

Actuated magnet has motion prescribed by user
Free magnet moves with its own inertia to align with actuated magnet
**Maxwell Transient Solver**

**Setup**

1. Draw a “band” around each object with independent motion
2. Assign axis of rotation and type of motion
Maxwell Transient Solver

Setup

3. Apply mesh operations
4. Specify time step and stop time
Maxwell Transient Solver

Setup
3. Plot flux lines
4. Plot motion and animate
Maxwell Transient Solver

Topic

- Define complex transient excitation with functions and datasets

1A Sinusoid + .15A Triangle
Maxwell Transient Solver

Steps

1. Define coil cross section as a ‘coil’ with turns.
2. Define winding with current function:
   - 1A*Sin(2*Pi*50*time) + 0.15A*pwl_periodic(ds1,time)

Periodic piecewise linear interpolation function of numeric dataset, defined by user.
Maxwell Transient Solver

Steps
• `pwl_periodic(ds1,time)` causes Maxwell to prompt for dataset definition
Maxwell Transient Solver

Resulting Current Waveforms

Input Current Waveform

Coil Back EMF

1A*Sin(2*Pi*50*time) + 0.15A*pwl_periodic(ds1,time)
Maxwell Transient Solver

Topic

- Define variable timestep to capture complex waveform shape.

Broadband excitation for sensing applications
Maxwell Transient Solver

Steps

1. Define coil cross section as a ‘coil’ with turns.
2. Define winding with current function:
   \[ 1 \text{A} \cdot \sin(2 \pi (1250 \cdot \text{time} + 50) \cdot \text{time}) \]

Frequency increases linearly from 50Hz to 150Hz in 8 fundamental periods.
Steps

3 Capture 30 steps per period, for 8 fund. periods
- $\frac{1}{30} \left( \frac{1}{1250 \times \text{time} + 50} \right)$
Outline

Maxwell
  – Geometry
  – Transient
  – Post-Processing

Simplorer
  – Transient Solver
  – Post-Processing
  – Advanced Analysis
Maxwell Post-Processing

Topic

• Use fields calculator to plot only Br in airgap for electric machine
Maxwell Post-Processing

Calculator
- Scalar Field: \( B_r = \vec{B} \cdot \vec{i}_r = (B_x \vec{i}_x + B_y \vec{i}_y) \cdot (\cos[\phi] \vec{i}_x + \sin[\phi] \vec{i}_y) \)
- Vector Field: \( \vec{B}_r = B_r \vec{i}_r = B_r (\cos[\phi] \vec{i}_x + \sin[\phi] \vec{i}_y) \)

Steps
- Define \( B_r \)
- Save \( B_r \) as a new Field Expression
- Define \( B_r_{\text{vec}} \) using \( B_r \)
- Save \( B_r_{\text{vec}} \) as a new Field Expression
Maxwell Post-Processing

Calculator: Define Br
- Input -> Quantity -> B
- Vector -> Scalar? -> ScalarX
- Input -> Function -> Phi
- Scalar -> Trig -> Cos
- General -> *
- Input -> Quantity -> B
- Vector -> Scalar? -> ScalarY
- Input -> Function -> Phi
- Scalar -> Trig -> Sin
- General -> *
- General -> +
- General -> Smooth
- Library -> Add... -> “Br”

Calculator: Define Br_Vector
- Named Expressions -> Br -> Library -> Copy to Stack
- Input -> Function -> Phi
- Scalar -> Trig -> Cos
- General -> *
- Scalar -> Vec? -> VecX
- Named Expressions -> Br-> Library -> Copy to Stack
- Input -> Function -> Phi
- Scalar -> Trig -> Sin
- General -> *
- General -> +
- Scalar -> Vec? -> VecY
- General -> +
- Library -> Add... -> “Br_vec”
Maxwell Post-Processing

Topic

• Graph the radial flux density in the gap
Maxwell Post-Processing

Steps
• Draw-> Arc -> 3 point Arc
• Create Fields Report
• Select the arc and Br

Radial Flux Density in Air Gap Over One Pole
Maxwell Post-Processing

Take Spatial FFT

Steps:

1. Right click Setup1 and select Perform FFT on Report
2. Select the flux density plot and select magnitude for the spectral plot.
Maxwell Post-Processing

Topic

• Display magnet operating point on BH curve
Maxwell Post-Processing

Steps
1. Export BH curve for Alnico5
2. Add header to BH text file
3. Solve design in iron or air fixture
Maxwell Post-Processing

Steps

4. Use calculator to define Hx and Bx
5. Draw a point to evaluate fields
6. Create fields report of Bx vs Hx at defined point
7. Import BH curve into report
8. Paste results from other simulations
Outline

Maxwell
  – Geometry
  – Transient
  – Post-Processing

Simplorer
  – Transient Solver
  – Post-Processing
  – Advanced Analysis
Simplorer Highlights

System Simulation

Multi-Domain Simulation

Mixed-Signal Simulation

Multi-Coupling Simulation
Simplorer Transient Solver

Topic: Enable on sheet live update for plots

- Tools > Options > Simplorer Options > General Options
### Simpler Post-Processing

**Topic: Create numerical display**

- Add display to schematic for instant numeric display of circuit gain
Simplorer Post-Processing

Steps
1. Create a data table
2. Pare To: Time Max
Simplorer Post-Processing

Steps

3 Drag plot onto schematic
Outline

Maxwell
- Geometry
- Transient
- Post-Processing

Simplorer
- Transient Solver
- Post-Processing
- Advanced Analysis
Simplorer Advanced Analysis

Topic: Statistical Analysis

• Vary component parameters to measure manufacturing variation on performance
Steps

1. Select properties for each resistor.
2. Select distribution for each resistor.
Steps

3. Add statistical analysis
4. Define Monte Carlo iterations
5. Define measured output
Simplorer Advanced Analysis

Steps

6 Execute statistical analysis
7 View analysis results
Simplorer Advanced Analysis

Topic: Import complex load waveforms from empirical data
• Reduce a complex sub-system to data from measurements.
Simplorer Advanced Analysis

Steps
1. Import text file as a dataset
2. Use datapairs block for dataset interpolation
3. Select the dataset in (1)
Simplorer Advanced Analysis

Steps
• Plot interpolated source and output.
Simplorer Advanced Analysis

Topic: Digitize datasheet information using the sheetscan tool.
• An automated approach to digitizing measured data for use in simulation.

Fig. 12 - Typ. Transfer Characteristics
V_{CE} = 50V, t_{p} = 10\mu s
Simplorer Advanced Analysis

Steps

1. In datasets window select sheetscan source
2. Picture -> Load Picture
Simplorer Advanced Analysis

Steps

3. Coordinate System -> New, Click to locate coordinate axes
4. Curve -> New, click to locate datapoints
5. File -> Export, to export text file
Workbench Coupling

Topic: Coupling Designs in Workbench
• Link the geometry and transfer heat dissipation from magnetics to thermal.
Workbench Coupling

Steps

1. Drag Geometry, Maxwell3D, and Steady State thermal blocks onto the schematic
2. Link Geometries and solutions by drag and dropping.
Workbench Coupling

1. Create your geometry
2. Setup and solve Maxwell
3. Setup and solve Thermal.
4. Coupling meshes is automatic, select which geometries to include.
Questions?