Position Sensor Simulation
with
ANSYS ® Maxwell 3D

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ANSYS Maxwell: Sensor Applications

- Hall Effect
  - Velocity, Position
- Variable Reluctance
  - Velocity, Position
- Magnetic Resistance
  - Velocity, Position
- Flux Gate
  - Proximity Sensing
  - Navigation
  - Velocity, Position
- Eddy Current
  - NDT (flaw detection)
Maxwell 3D: Example Nonlinear Magnetostatic Analysis

- Adaptive meshing for most automated and precise analysis
- Parametrized setup
- Extended Postprocessing with fields calculator
Simplorer: Example Circuit Simulation

Maxwell 3D Link

Difference := FLUXM2.FLUX - FLUXM1.FLUX

Spacings = 3mm
Non Differential Signal Detected

Spacings = 1mm
Differential Signal Detected
Object of Interest

- Position Sensor (MR)
  - Used widely in automotive sector
  - Low cost

- Some sensor parameters
  - Angular position
  - Positioning error
    - Axial
    - Angular

Source: ANSYS
**Principle**

- Magnetoresistive (MR) sensor element with gear wheel.
- Resistance changes with the angles which the magnetic field which crosses
- the direction of current accomplishes.
- Bridge connection of each resistance.
- No thermal effects.
- No deformation, eddy current effects.

\[
R = R_0 + \Delta R \cos^2(\alpha)
\]

\[
\begin{align*}
\alpha &= 0^\circ \Rightarrow R_{\text{max}} \\
\alpha &= 90^\circ \Rightarrow R_{\text{min}}
\end{align*}
\]
Maxwell: Process

- Use Maxwell 3D
  - MagnetoStatic + Optimetrics

- Linear permeability for valid parameter.

- Variable parameter about a gear rotation angle.
  - Change rotation angle of object to a variable.

- Integrate magnetic field intensity of a sensor object.
  - Calculates using a function of Calculator.

- Export Design Variation with Workbench
  - Data is manually processed using a function of Table I/O.
Maxwell: Simulation Details

- Rotation angle of Wheel
- Permeability of a deficit part
Maxwell: Simulation Details

- Use of Field Calculator

\[
\alpha = \tan^{-1} \left( \frac{\int H_y \, dv / V}{\int H_x \, dv / V} \right)
\]
Position Sensor-Simulation with ANSYS® Maxwell 3D

(Hands-On Notes)
Workbench: Simulation Process

- Efficient use of hardware resources for parameter variations
  - HPC parallel computation with ANSYS
  - Types of processing with ANSYS
  - Example scenario
ANSYS HPC Parametric Pack

Time reduction for a parametric study

HPC parametric packs amplify both solver licenses and HPC licenses allowing you to drastically reduce time to innovation.
## Types of Processing

<table>
<thead>
<tr>
<th>Local</th>
<th>Remote</th>
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<tbody>
<tr>
<td><strong>1. All Processes Local</strong></td>
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<td>Result Processing</td>
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| **2. Local Pre/Post and Remote Solve Process** | |
| Geometry Update | |
| Meshing Process | |
| Boundary Conditions Mapping | |
| Result Extraction | |
| Result Processing | |
| Solution Process | | |

| **3. Main Processes Remote** | |
| Geometry Update | |
| Meshing Process | |
| Boundary Conditions Mapping | |
| Solution Process | |
| Result Extraction | |
| Result Processing | |
# 1. All Processes Local

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1. All Processes Local

- All design points are calculated sequentially which means step by step (NO simultaneous processes)

- Solution Process:
  - Update Option: Use application default

- Design Point Update Process:
  - Update Option: Run in Foreground
2. Local Pre/Post and Remote Solve Process

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Results as rst-file (large)
2. Local Pre/Post and Remote Solve Process

- All design points are calculated sequentially which means step by step (NO simultaneous processes)

- Solution Process:
  - Update Option: Submit to Remote Solve Manager

- Design Point Update Process:
  - Update Option: Run in Foreground
3. Main Processes Remote

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<td>extracted Results as table (small)</td>
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3. Main Processes Remote

- All design points are calculated sequentially or simultaneously

- Solution Process:
  - Update Option: Use application default → Compute Server

- Design Point Update Process:
  - Update Option: Submit to Remote Solve Manager → Compute Server

- Processing order defined by 3 types of settings (see following slides)
3. Main Processes Remote

2\textsuperscript{nd} Type: One Job Each Design Point

- Number of jobs is equal to design points
  - e.g. 32 design points $\rightarrow$ 32 jobs
- Jobs can be processed sequentially or simultaneously, depending on licensing and RSM settings
3. Main Processes Remote

3rd Type: Specify Maximum Number of Jobs

- Maximum number of jobs is limited
- Jobs can be processed sequentially or simultaneously, depending on licensing and RSM setting
Example

Simultaneous Processing with ANSYS HPC Parametric Pack

- 32 core remote compute server machine
- 1 x ANSYS HPC Parametric Pack
- 1 x ANSYS HPC Pack
- 1 x ANSYS Mechanical
- 100 design points
- Geometry parameters + load parameters

Recommended Setup
Simultaneous Processing with ANSYS HPC Parametric Pack

Example
Simultaneous Processing with ANSYS HPC Parametric Pack
Simultaneous Processing with ANSYS HPC Parametric Pack

Summary

- Simultaneous processing enabled by
  - “Reserved Licenses”
  - Specified Maximum Number of Jobs: 4
  - ANSYS HPC Parametric Pack

- All geometries are updated locally upfront

- 4 jobs in process (each job includes 25 design points), 0 jobs in RSM-Queue

- 8 cores per job → 32 cores in process; enabled by ANSYS HPC Pack

- Specified Maximum Number of Jobs < RSM Limiter → Golden Rule
ANSYS Maxwell: Integration into Workbench

- Maxwell 3D
- Maxwell 2D
- Quasi-static Solvers
- Harmonic Solver
- Electric Transient
- Magnetic Transient Solver
- Multiprocessing
- Spectral Domain
- Distributed Solve Option (DSO)
- Parametric
- Sensitivity
- Optimization
- Statistical
DSO Terminology for EM

- R14: ANSYS 14, Maxwell 15
- Regular DSO: the parametric DSO feature that is available in R13 and earlier versions
- Large Scale DSO: parametric DSO that solves variations in an embarrassingly-parallel manner, without any centralized bottlenecks.
Additional Function: System Simulation

- **Motivation:**
  - Include different physical effects
    - magnetic-thermal / cfd
    - magnetic-electric circuit
    - magnetic-mechanic
  - Use existing (detailed) know how including nonlinearity
  - Save simulation time
  - Share data between departments
Maxwell to Simploterer

- Exporting Lookup Table
  - Export as format of Table.
  - Data is manually processed by other tools. (e.g. Excel)
  - Reload as Table → Export SML.

Export from Parametric Solutions

Export from Imported Table

Result table file: Starting Angle – End Angle

Result table file: Merged as Complete one round.
Simplorer: System Simulation (Overview)

- **Sensor output Voltage**: The voltage output from the sensor is shown with a waveform that indicates a periodic signal, typically representing the sensor's response to rotational movement.
- **Amplified Output**: The amplified output is depicted with a waveform that shows an increased magnitude compared to the sensor output, indicating the sensor's signal has been processed through an amplifier.

The diagram includes various components such as a sensor, amplifier, and various voltage monitors (VM1.V, VM6.V) with specific values and waveforms. The sensor's sensitivity and amplified output are highlighted, showing the process of converting physical movement into electrical signals and then amplifying them.