



PARTNERSHIP FOR  
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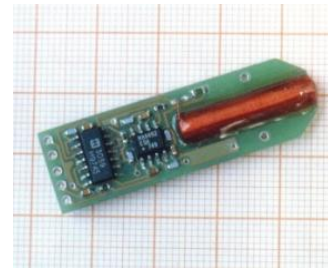
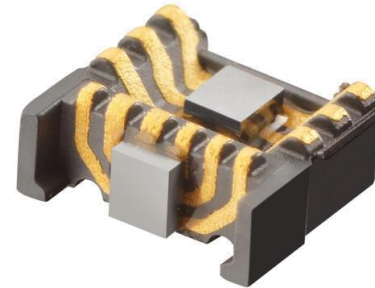
# Position Sensor Simulation with ANSYS<sup>®</sup> Maxwell 3D

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**PRACE Autumn School 2013 - Industry Oriented HPC Simulations, September 21-27, University of Ljubljana, Faculty of Mechanical Engineering, Ljubljana, Slovenia**

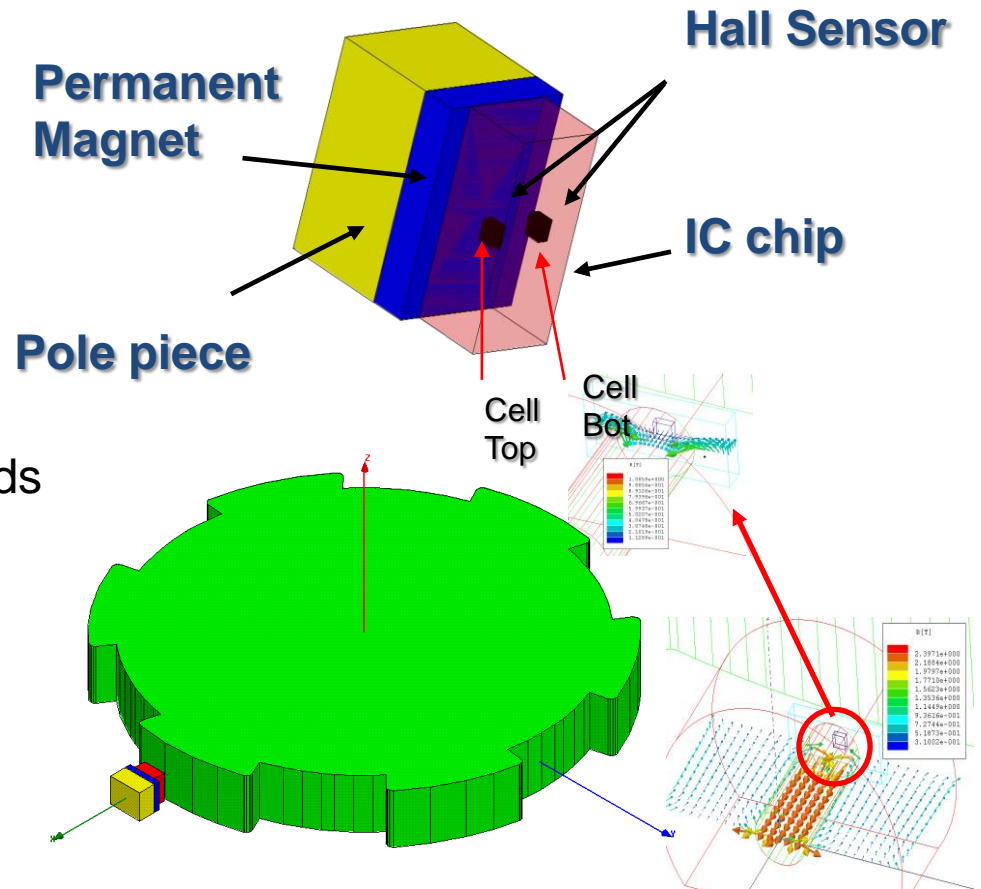
# ANSYS Maxwell: Sensor Applications

- Hall Effect
  - Velocity, Position
- Variable Reluctance
  - Velocity, Position
- Magnetic Resistance
  - Velocity, Position
- Flux Gate
  - Proximity Sensing
  - Navigation
  - Velocity, Position
- Eddy Current
  - NDT (flaw detection)

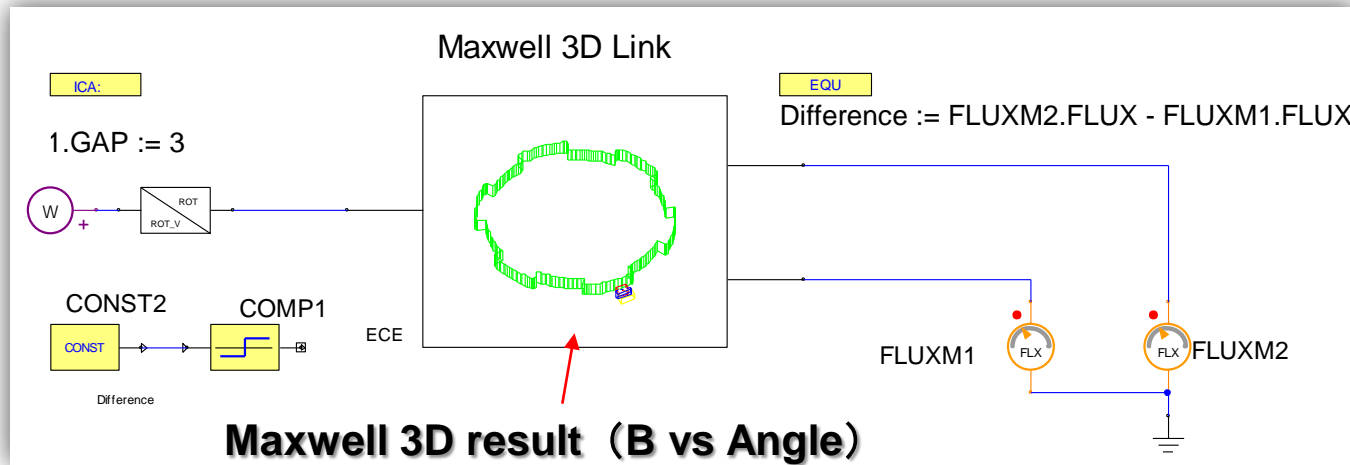


# Maxwell 3D: Example Nonlinear Magnetostatic Analysis

- Adaptive meshing for most automated and precise analysis
- Parametrized setup
- Extended Postprocessing with fields calculator

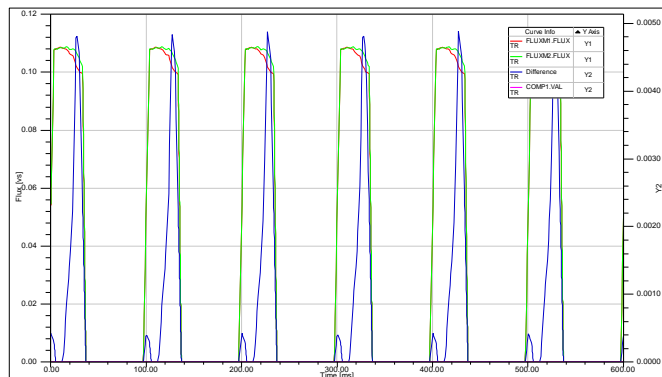


# Simplorer: Example Circuit Simulation



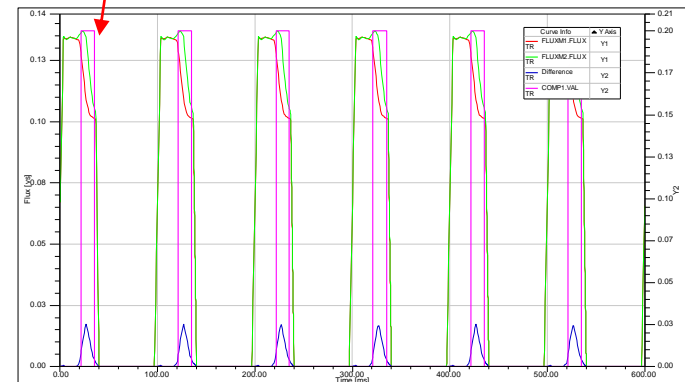
Spacing = 3mm

Non Differential Signal Detected



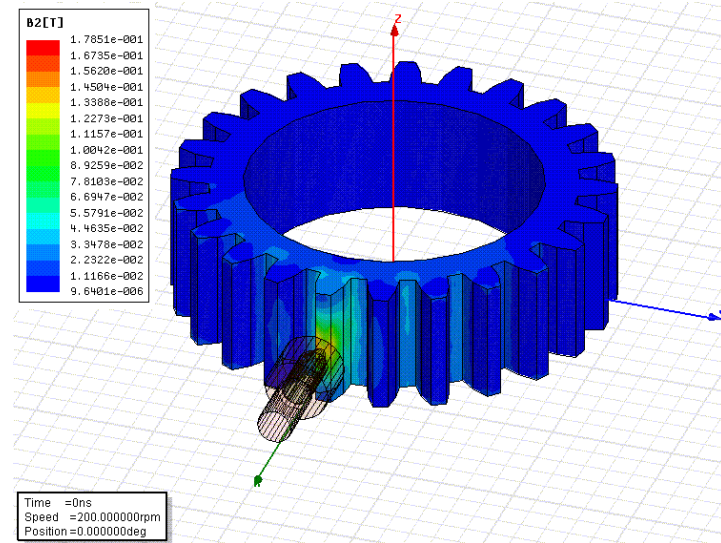
Spacing = 1mm

Differential Signal Detected

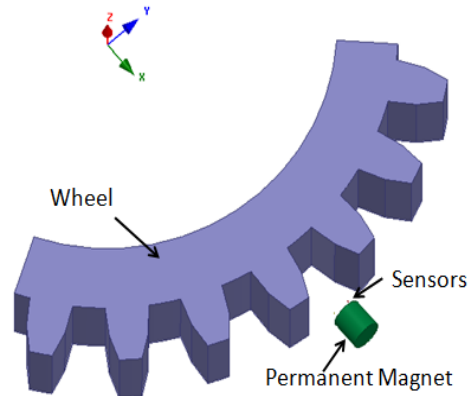


# Object of Interest

- Position Sensor (MR)
  - Used widely in automotive sector
  - Low cost
- Some sensor parameters
  - Angular position
  - Positioning error
    - Axial
    - angular

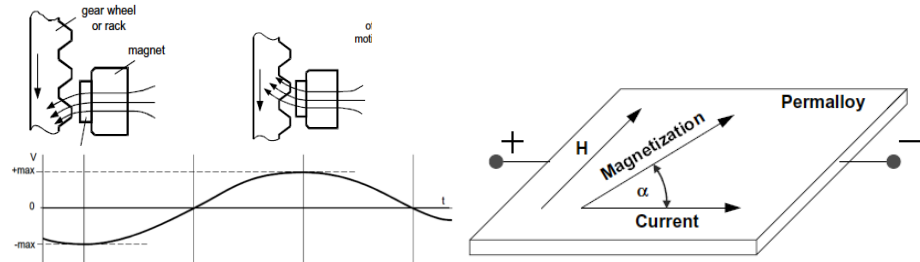


Source: ANSYS



# Principle

- Magneto-resistive(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.

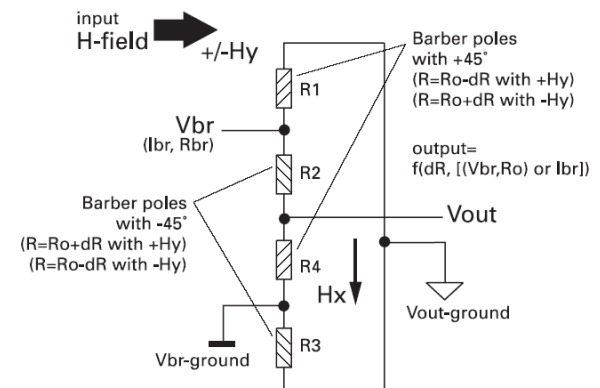


$$R = R_0 + \Delta R \cos^2 \alpha$$

$$\alpha = 0^\circ \Rightarrow R_{\max}$$

$$\alpha = 90^\circ \Rightarrow R_{\min}$$

## AMR-bridge



## 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

Properties: MRsensor\_Prm2 - MaxwellDesign1 - 3D Modeler

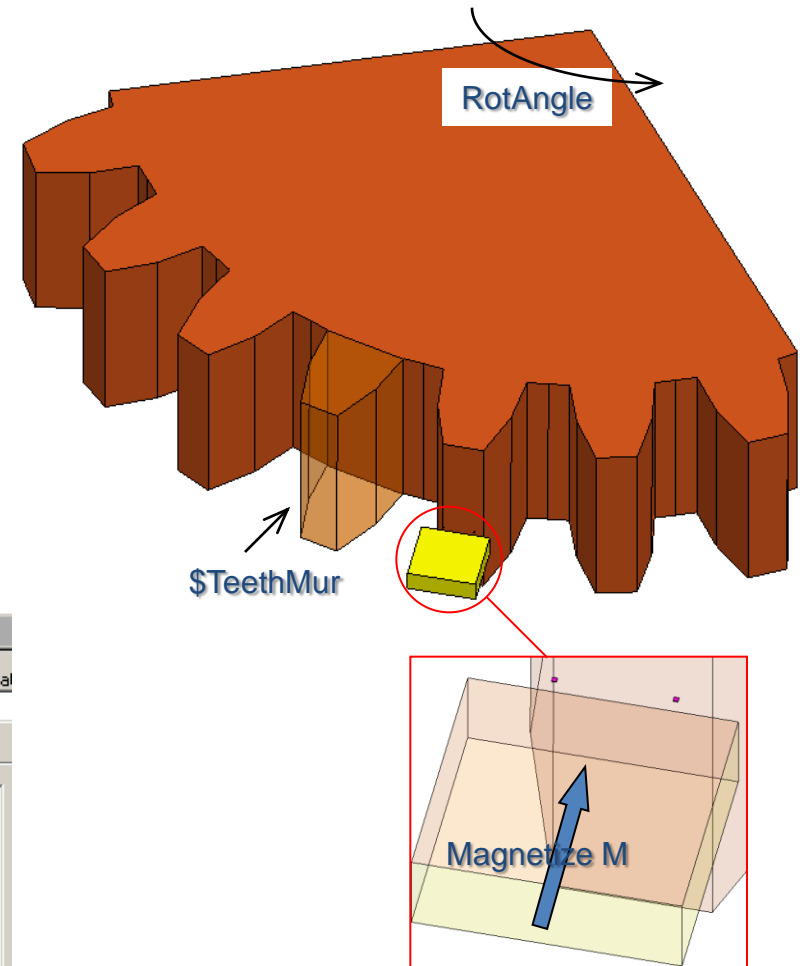
Name	Value	Unit	Evaluated ...
Command	Rotate		
Coordinate System	Global		
Axis	Z		
Angle	RotAngle	-15deg	

View / Edit Material

Material Name: iron\_teeth  
Material Coordinate System: Cartesian

Properties of the Material

Name	Type	Value	Units
Relative Permeability	Simple	\$Teeth_Mur	
Bulk Conductivity	Simple	10300000	siemens/m
Magnetic Coercivity	Vector		
- Magnitude	Vector Mag	0	A_per_meter
Composition		Solid	

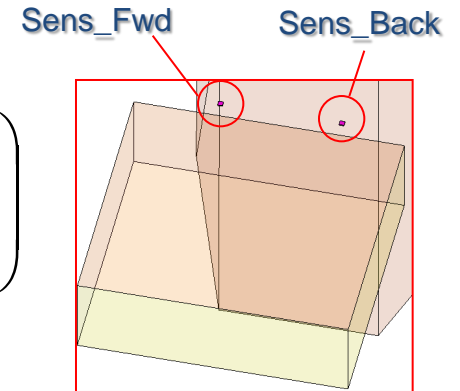




# Maxwell: Simulation Details

- Use of Field Calculator

$$\alpha = \tan^{-1} \left( \frac{\int H_y dv / V}{\int H_x dv / V} \right)$$



Objects

- iron
  - target\_wheel\_1
    - Import
    - Rotate
  - iron\_teeth
    - target\_wheel\_teeth
      - Import
      - Rotate
- NdFe30
- vacuum
- Coordinate Systems
- Planes
- Lists

Properties: MRsensor\_Prm2 - MaxwellDesign1 - 3D Modeler

Name	Value	Unit	Evaluated ...
Command	Rotate		
Coordinate System	Global		
Axis	Z		
Angle	RotAngle	-15deg	

View / Edit Material

Material Name: iron\_teeth    Material Coordinate System: Cartesian

Properties of the Material

Name	Type	Value	Units
Relative Permeability	Simple	\$Teeth_Mur	
Bulk Conductivity	Simple	10300000	siemens/m
Magnetic Coercivity	Vector		
- Magnitude	Vector Mag	0	A_per_meter
Composition		Solid	

## Operation of Calculator.

Qty · H · Scalar · Y  
Geom · Sens\_Fwd · Integ

Qty · H · Scalar · X  
Geom · Sens\_Fwd · Integ

/

Trig · Atan

Constant · PI · /  
Number · 180.0 · \*

[Add] → Ang\_Fwd

# HANDS-ON

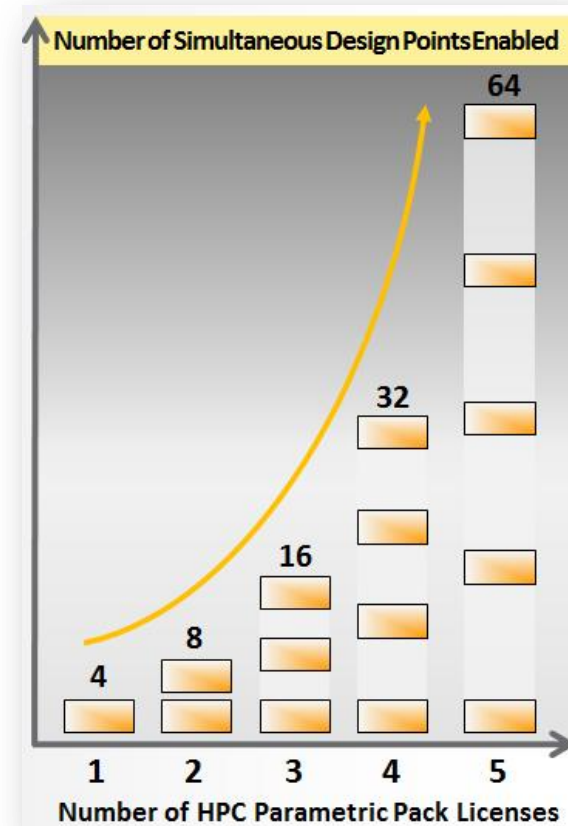
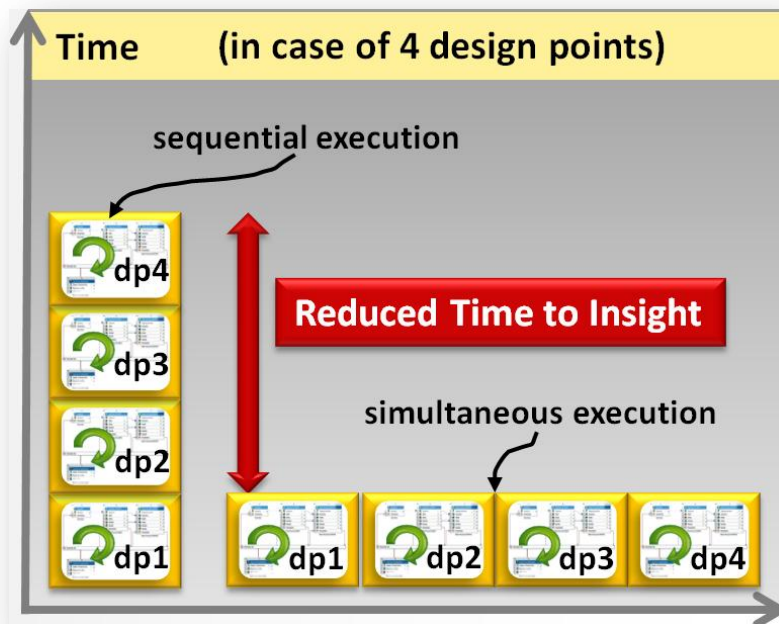


## Position Sensor-Simulation with ANSYS® Maxwell 3D (Hands-On Notes)

HANDS-ON-Position-Sensor-Simulation-with Maxwell3D.docx

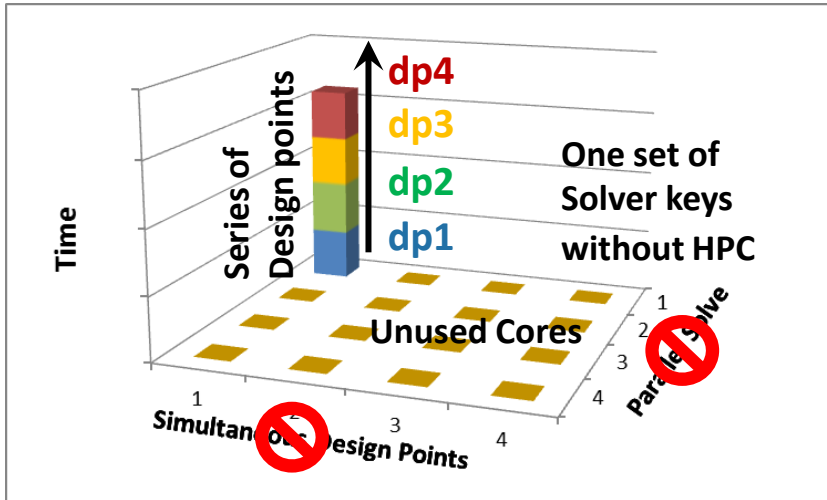
# Workbench: Simulation Process

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

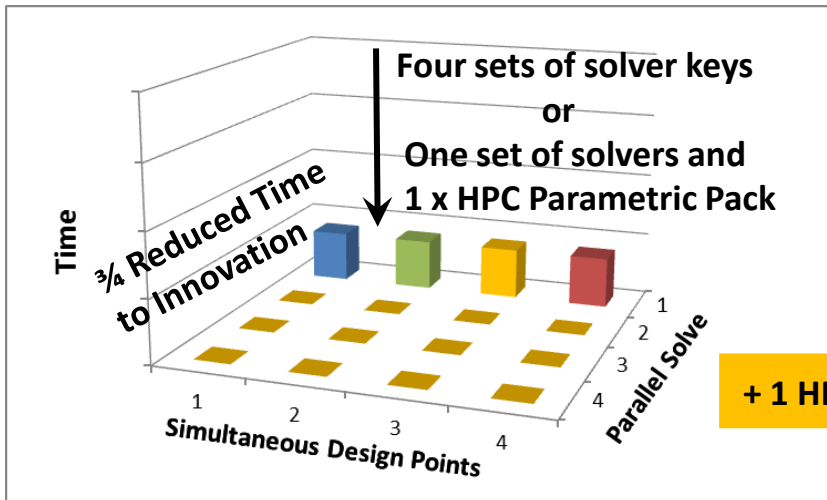


# ANSYS HPC Parametric Pack

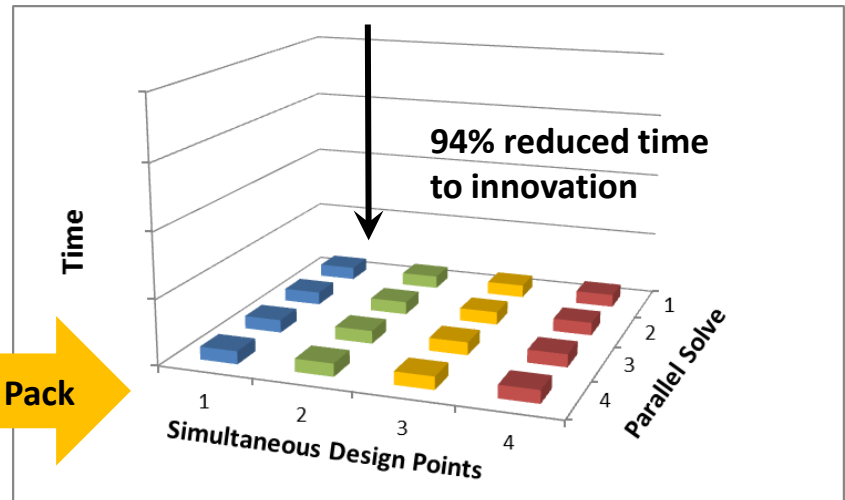
## Time reduction for a parametric study



HPC parametric packs amplify both solver licenses and HPC licenses allowing you to drastically reduce time to innovation



+ 1 HPC Pack



# Types of Processing

**Local**

**Remote**

## 1. All Processes Local

Geometry Update  
Meshing Process  
Boundary Conditions Mapping  
Solution Process  
Result Extraction  
Result Processing

## 2. Local Pre/Post and Remote Solve Process

Geometry Update  
Meshing Process  
Boundary Conditions Mapping

Solution Process

Result Extraction  
Result Processing

## 3. Main Processes Remote

Geometry Update

Meshing Process  
Boundary Conditions Mapping  
Solution Process  
Result Extraction

Result Processing

# 1. All Processes Local

## Local

## Remote

- Geometry Update
- ↓
- Meshing Process
- ↓
- Boundary Conditions Mapping
- ↓
- Solution Process
- ↓
- Result Extraction
- ↓
- Result Processing

# 1. All Processes Local

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

The image shows two screenshots of the ANSYS Workbench interface. The left screenshot shows the 'Properties of Schematic A6: Solution' dialog box. The 'Solution Process' section is expanded, and the 'Update Option' is set to 'Use application default'. The right screenshot shows the 'Properties of Schematic: Parameter Set' dialog box. The 'Design Point Update Process' section is expanded, and the 'Update Option' is set to 'Run in Foreground'. Both sections are highlighted with red boxes.

	A	B
1	Property	Value
2	General	
3	Component ID	Solution
4	Directory Name	SYS
5	Notes	
6	Notes	
7	Used Licenses	
8	Last Update Used Licenses	ANSYS Mechanical
9	System Information	
10	Physics	Structural
11	Analysis	Static Structural
12	Solver	Mechanical APDL
13	Solution Process	
14	Update Option	Use application default
15	Solve Process Setting	Eigener Computer
16	Solve Manager	
17	Queue	

	A	B
1	Property	Value
2	Design Point Update Process	
3	Update Option	Run in Foreground
4	Design Point Update Order	Update from Current
5	License Checkout	On-demand

- Solution Process:
  - Update Option: Use application default → Local
- Design Point Update Process:
  - Update Option: Run in Foreground → Local

## 2. Local Pre/Post and Remote Solve Process

### Local

### Remote

- Geometry Update



- Meshing Process



- Boundary Conditions Mapping



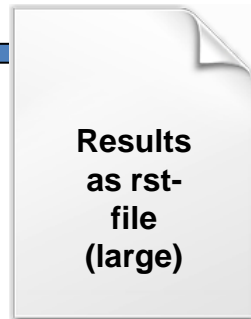
- Solution Process



- Result Extraction



- Result Processing





## 2. Local Pre/Post and Remote Solve Process

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

The first screenshot shows the 'Properties of Schematic A6: Solution' table. The 'Solution Process' row is highlighted with a red box, and its 'Update Option' is set to 'Submit to Remote Solve Manager'.

	A	B
1	Property	Value
2	General	
3	Component ID	Solution
4	Directory Name	SYS
5	Notes	
6	Notes	
7	Used Licenses	
8	Last Update Used Licenses	ANSYS Mechanical
9	System Information	
10	Physics	Structural
11	Analysis	Static Structural
12	Solver	Mechanical APDL
13	Solution Process	
14	Update Option	Submit to Remote Solve Manager
15	Solve Process Setting	Eigener Computer, Hintergrund
16	Solve Manager	localhost
17	Queue	Local

The second screenshot shows the 'Properties of Schematic: Parameter Set' table. The 'Design Point Update Process' row is highlighted with a red box, and its 'Update Option' is set to 'Run in Foreground'.

	A	B
1	Property	Value
2	Design Point Update Process	
3	Update Option	Run in Foreground
4	Design Point Update Order	Update from Current
5	License Checkout	On-demand

- Solution Process:
  - Update Option: Submit to Remote Solve Manager → Compute Server
- Design Point Update Process:
  - Update Option: Run in Foreground → Local

### 3. Main Processes Remote

#### Local

- Geometry Update



#### Remote

- Meshing Process



- Boundary Conditions Mapping



- Solution Process



- Result Extraction

- Result Processing



extracted  
Results  
as table  
(small)

### 3. Main Processes Remote

- All design points are calculated sequentially or simultaneously

The figure consists of four screenshots from the ANSYS Workbench interface:

- Top Left:** Project Schematic showing the hierarchy: Static Structural (A) -> Parameters -> Parameter Set.
- Top Middle:** Properties of Schematic A6: Solution. The 'Solution Process' section is highlighted with a red box, showing:
 

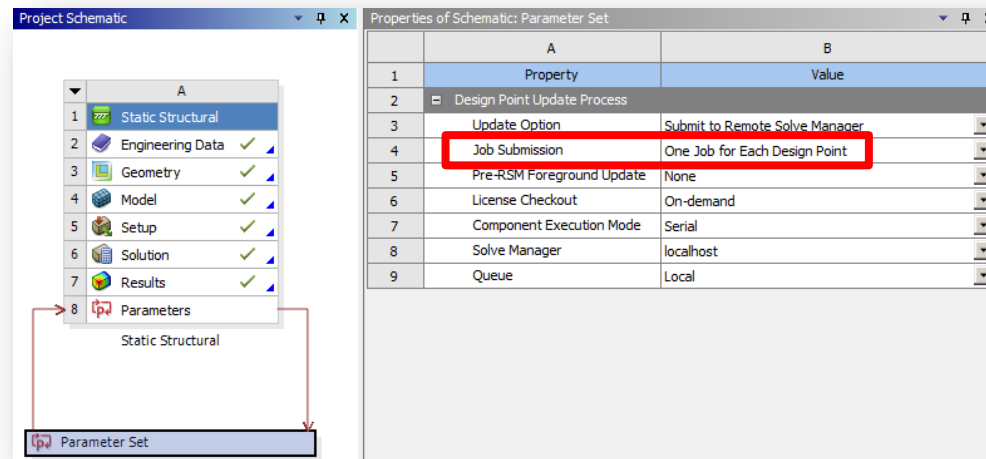
Property	Value
Update Option	Use application default
Solve Process Setting	Eigener Computer
- Top Right:** Project Schematic showing the hierarchy: Static Structural (A) -> Parameters -> Parameter Set.
- Bottom Right:** Properties of Schematic: Parameter Set. The 'Design Point Update Process' section is highlighted with a red box, showing:
 

Property	Value
Update Option	Submit to Remote Solve Manager

- 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

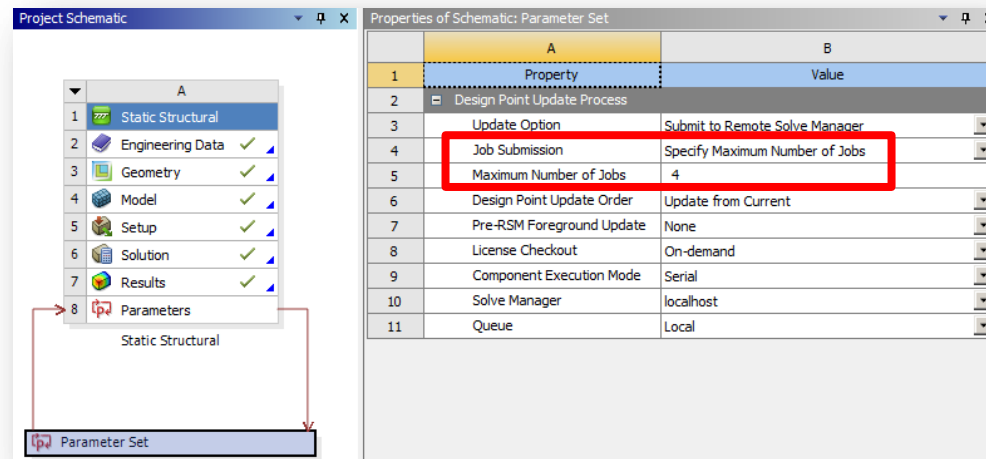
### 2<sup>nd</sup> Type: One Job Each Design Point



- Number of jobs is equal to design points
  - e. g. 32 design points → 32 jobs
- Jobs can be processed sequentially or simultaneously, depending on licensing and RSM settings

## 3. Main Processes Remote

### 3<sup>rd</sup> 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

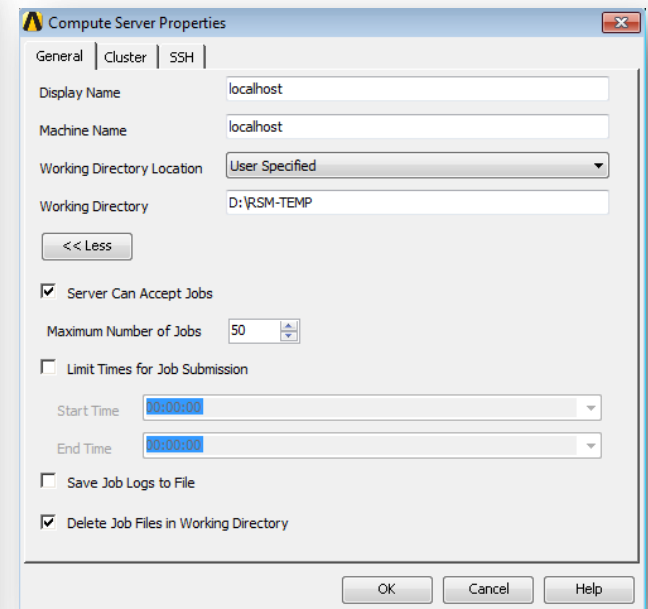
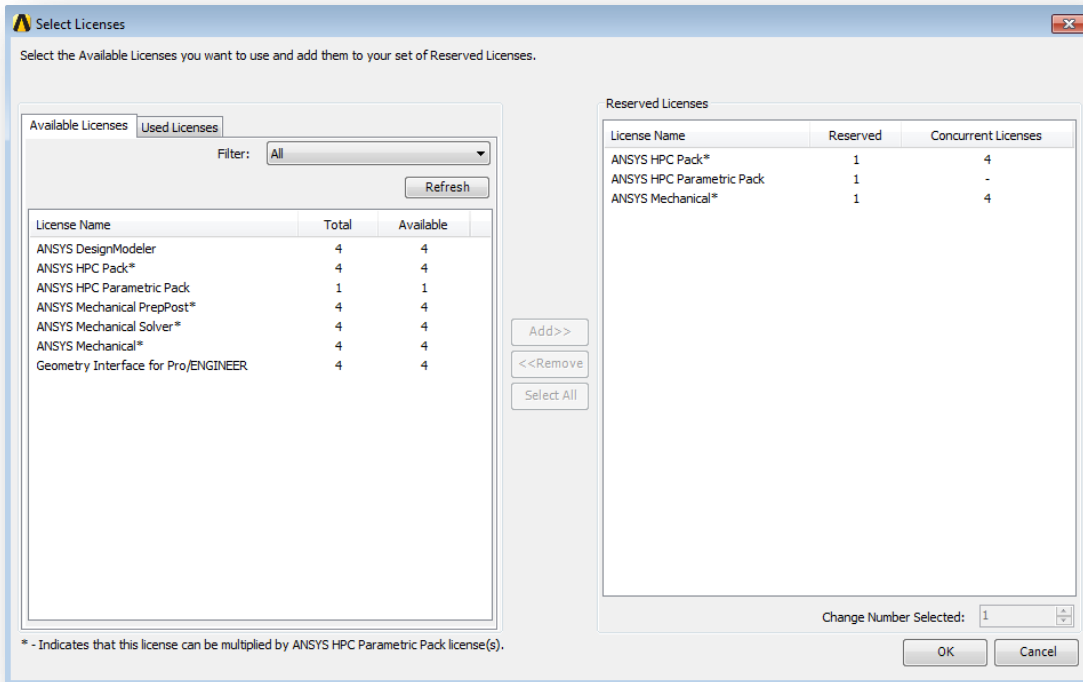
## Recommended Setup

	A	B
1	Property	Value
2	General	
3	Component ID	Solution
4	Directory Name	SYS
5	Notes	
6	Notes	
7	Used Licenses	
8	Last Update Used Licenses	ANSYS Mechanical
9	System Information	
10	Physics	Structural
11	Analysis	Static Structural
12	Solver	Mechanical APDL
13	Solution Process	
14	Update Option	Use application default
15	Solve Process Setting	Eigener Computer
16	Solve Manager	

	A	B
1	Property	Value
2	Design Point Update Process	
3	Update Option	Submit to Remote Solve Manager
4	Job Submission	Specify Maximum Number of Jobs
5	Maximum Number of Jobs	4
6	Design Point Update Order	Update from Current
7	Pre-RSM Foreground Update	Geometry
8	License Checkout	Reserved
9	Reserved License Set	Select Licenses
10	Component Execution Mode	Parallel
11	Max Number of Processes Per Job	8
12	Solve Manager	localhost
13	Queue	Local

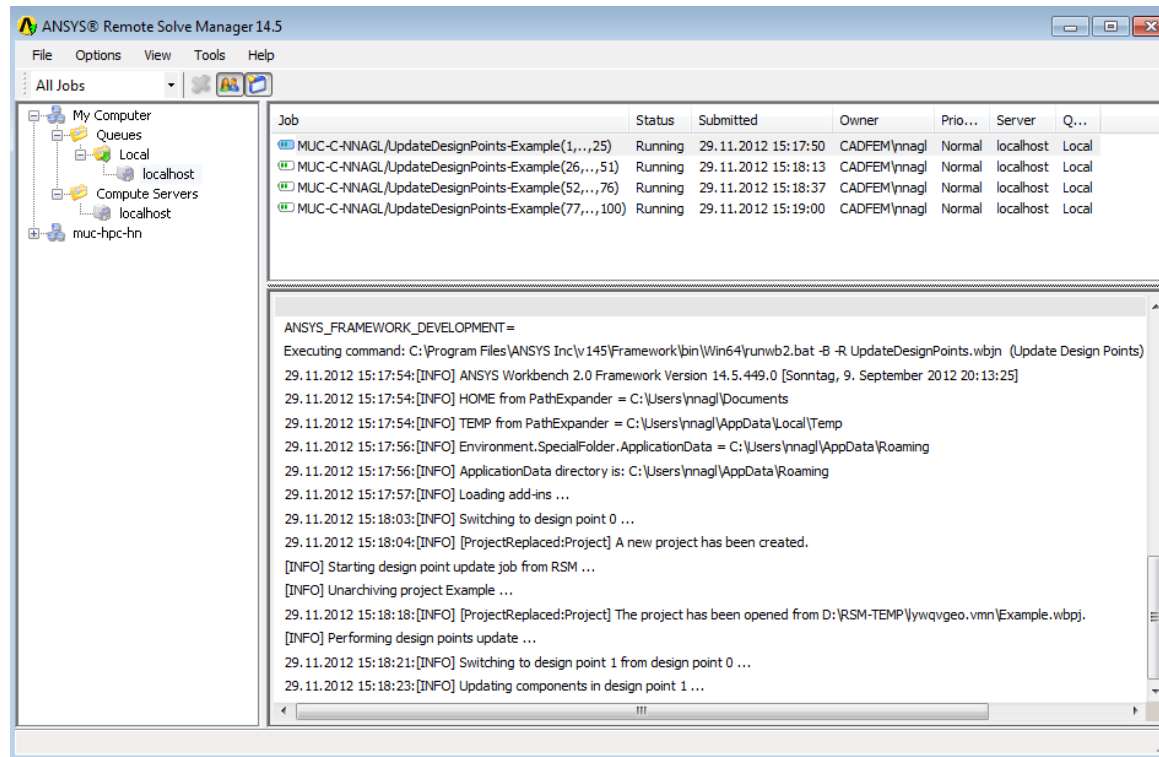
# Example

## Simultaneous Processing with ANSYS HPC Parametric Pack



# Example

## Simultaneous Processing with ANSYS HPC Parametric Pack





## Example

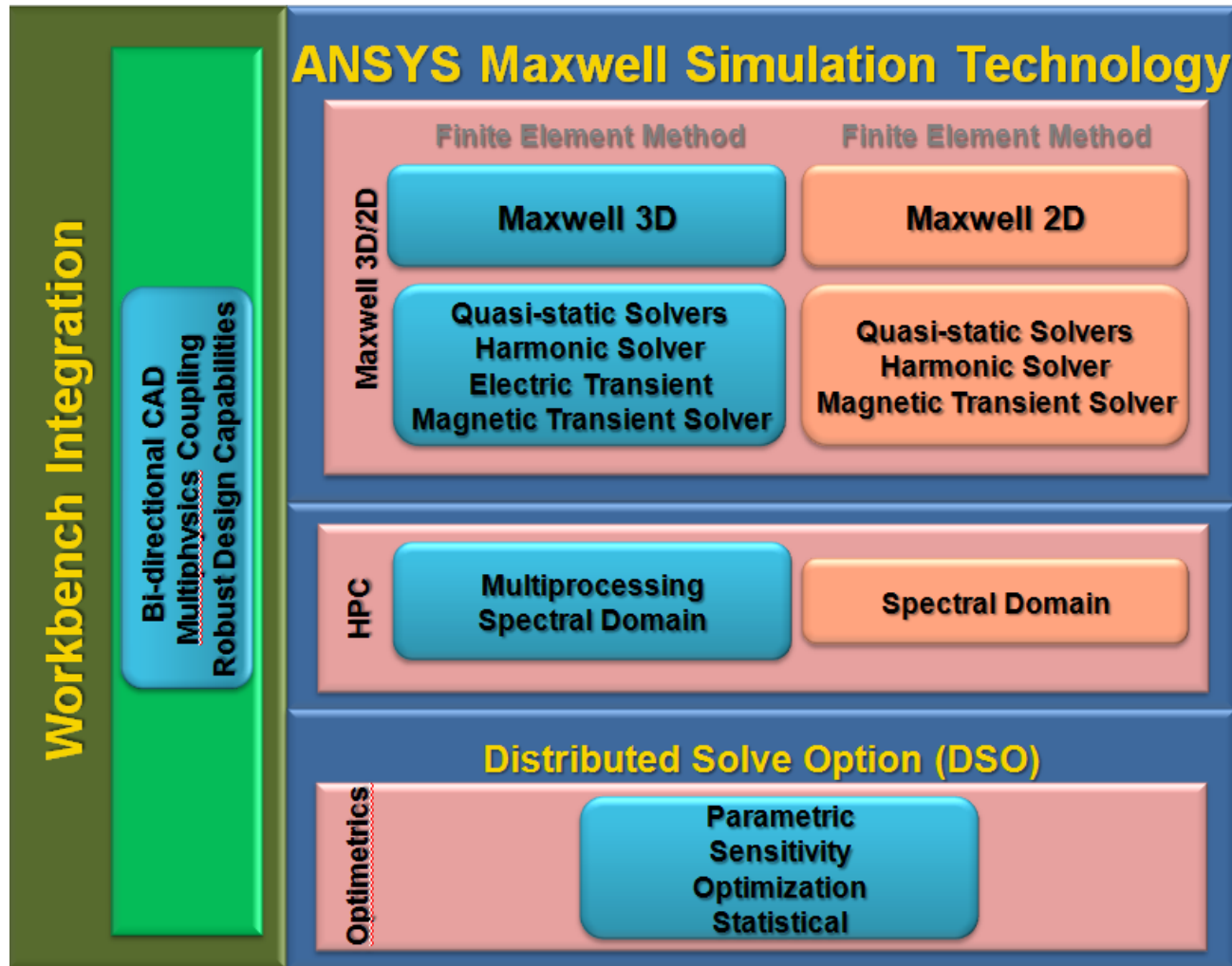
### Simultaneous Processing with ANSYS HPC Parametric Pack

#### 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

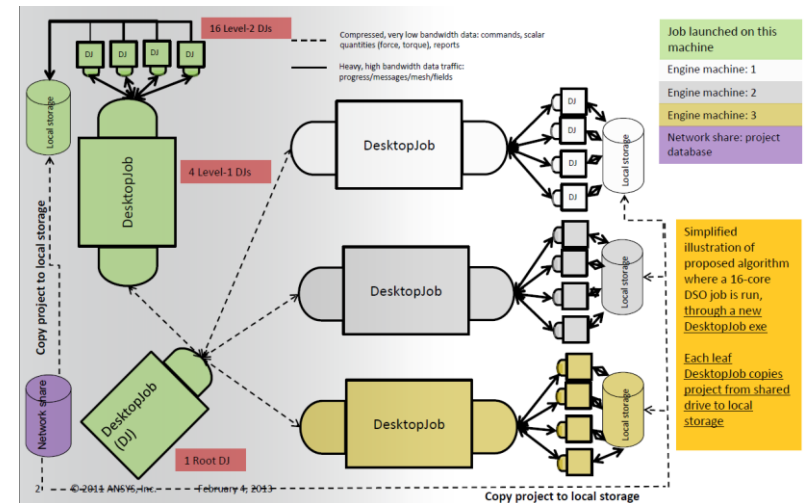
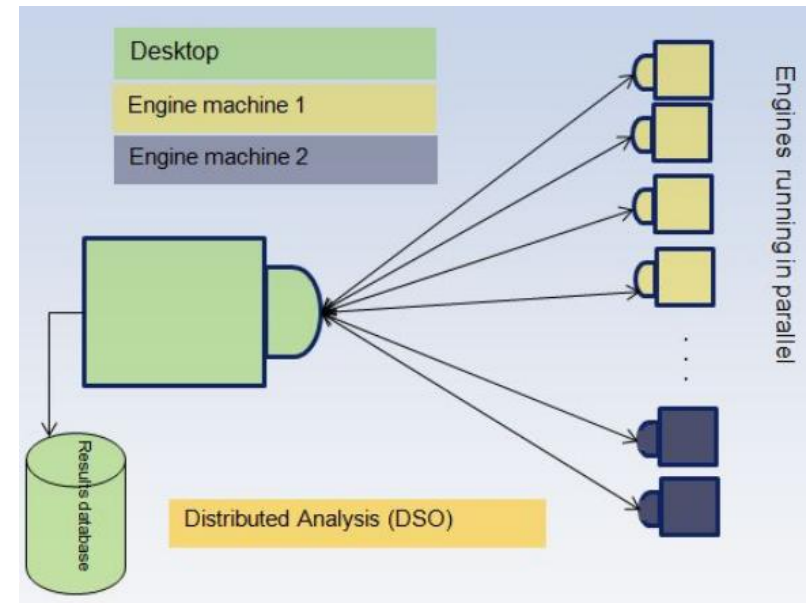


# ANSYS Maxwell: Integration into Workbench



# 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.



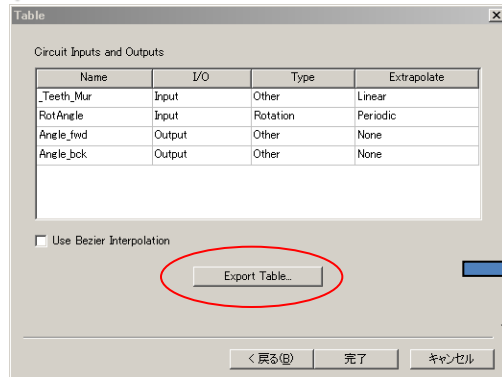
# Additional Function: System Simulation

- 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

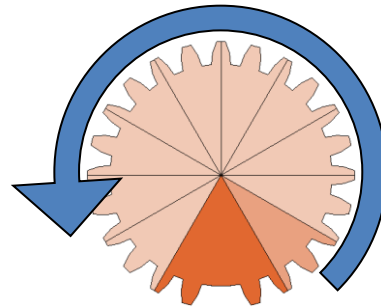
# Maxwell to Simplorer

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

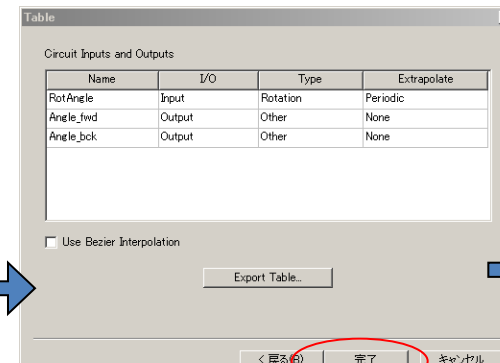
## Export from Parametric Solutions



Result table file :  
Starting Angle – End Angle



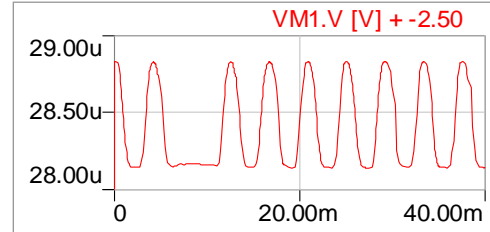
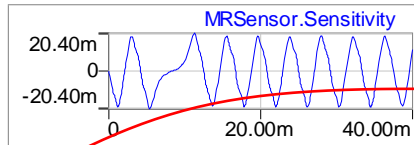
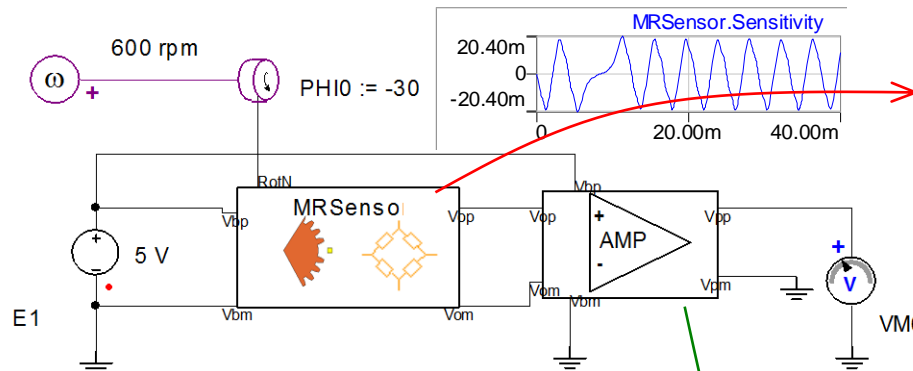
## Export from Imported Table



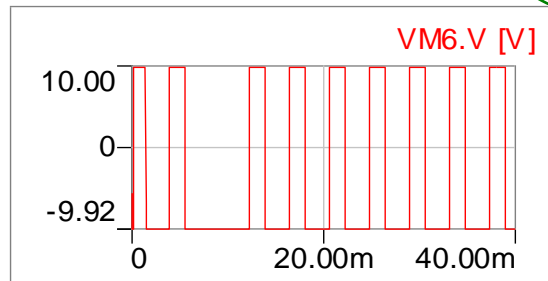
Result table file :  
Merged as Complete one round.



# Simplorer: System Simulation (Overview)



Sensor output Voltage.



Amplified Output.

