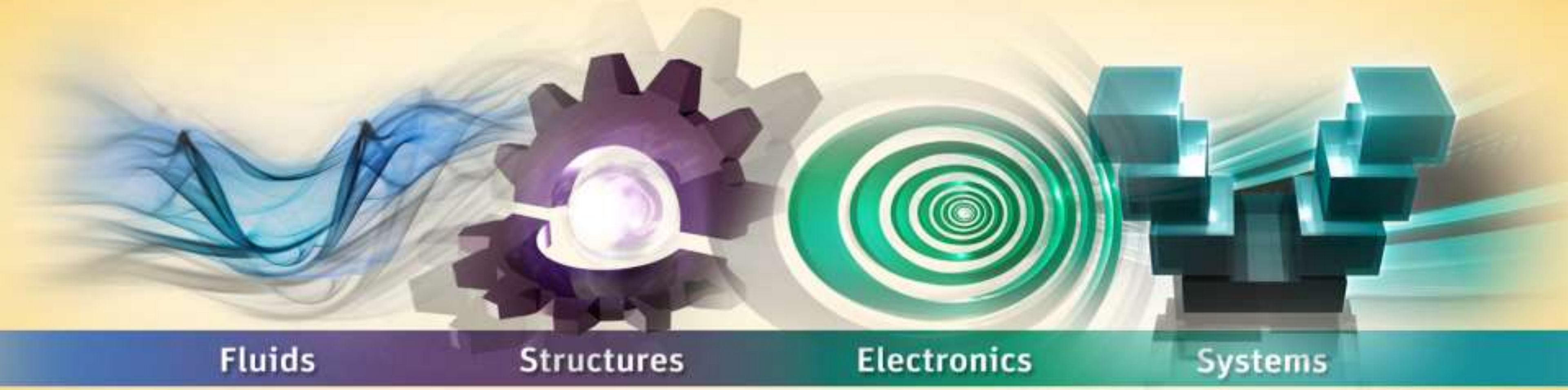
Einsatz von optiSLang in der Elektrotechnik



Gerd Prillwitz
Senior Application Eng.
ANSYS Inc.

Outline

Challenges in Virtual Prototyping

Methods in optiSLang

Example Application

ANSYS

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Example Application

Why do we need Robust Design Optimization?

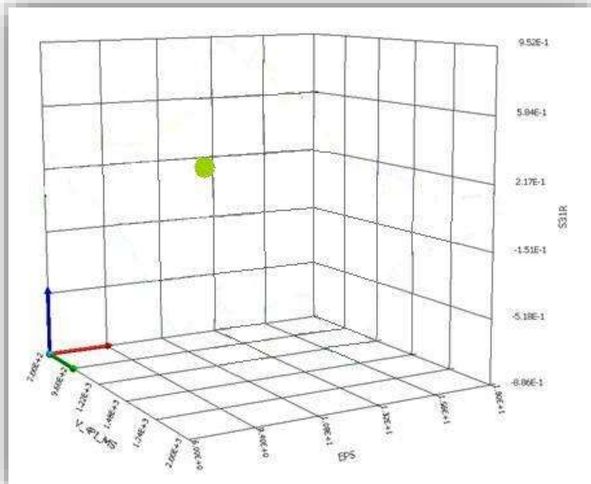
In reality tolerances, uncertainties and variability exist caused by environmental influences, load variation or human inaccuracy.

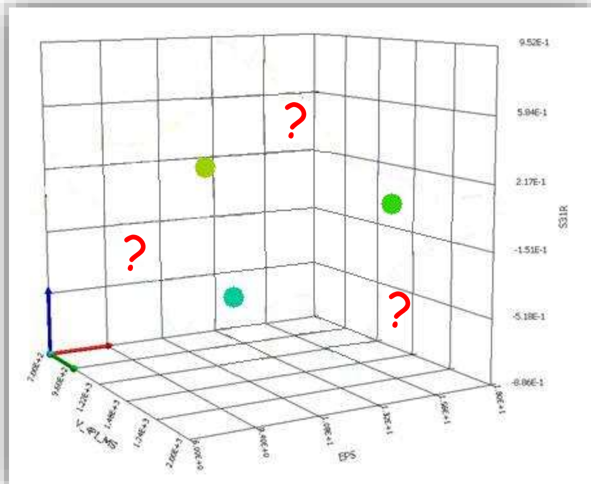
- **These kind of unpredictable influences cause uncertainties in the desired product functionalities**
- **Goal: Understand the these scattering parameters → guarantee the product functionalities of an optimized design in spite of these uncertainties**

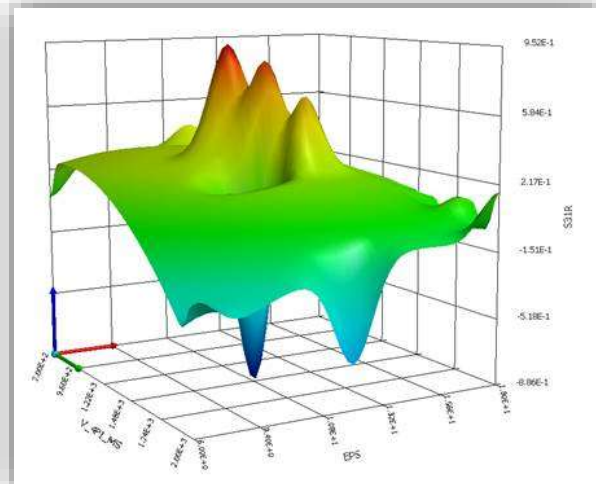
Uncertainties

ANSYS Design Exploration

- **Simulation shows result for certain design point**
- **What happens if parameter are changed?**
- **Response Surface shows result for parameter space**







Single Point → ***What If?*** → ***Response Surface***

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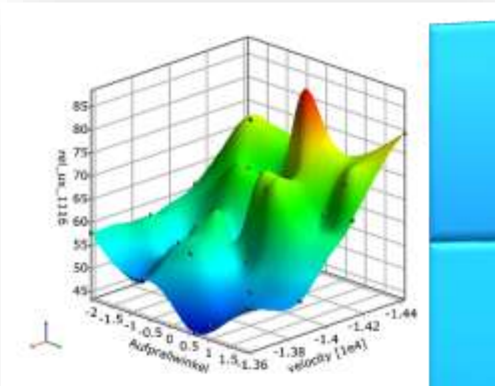
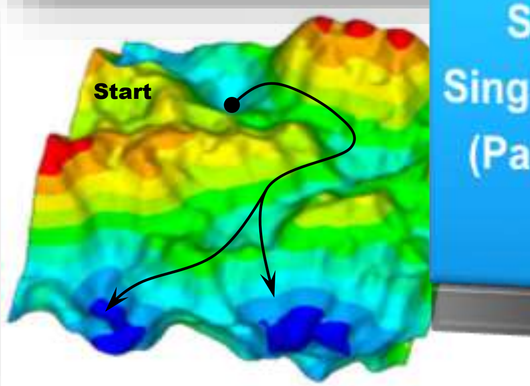
Methodology Definition

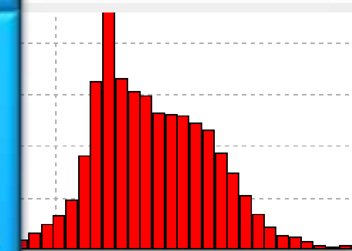


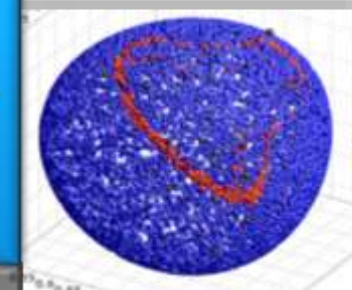


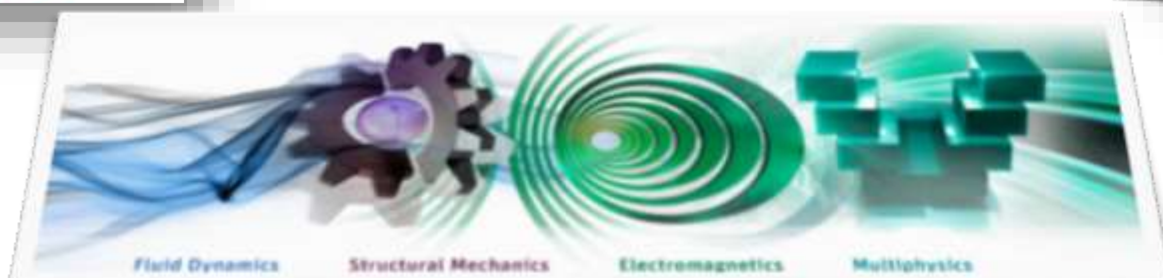
Robust Design Optimization

Optimization:
Sensitivity Study
Single & Multi objective
(Pareto) optimization

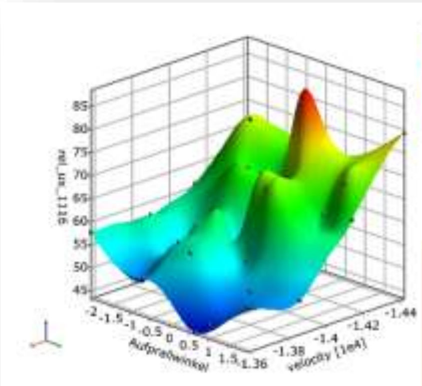
Robust Design:
Variance based Robustness Evaluation
Probability based Robustness Evaluation (Reliability analysis)

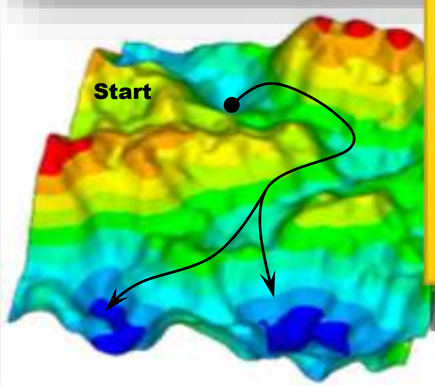






Methodology Definition





Robust Design Optimization

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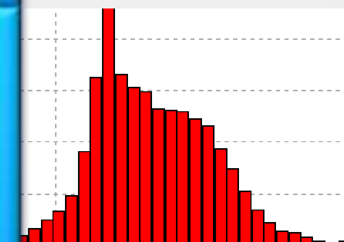
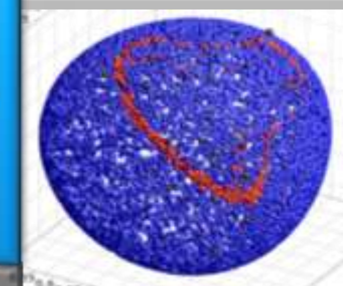
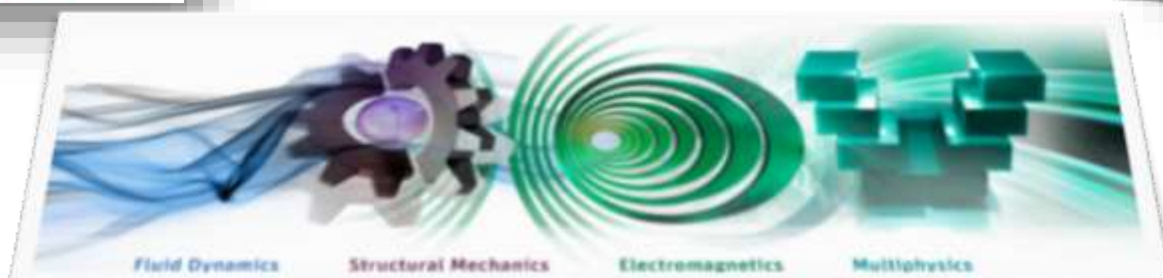






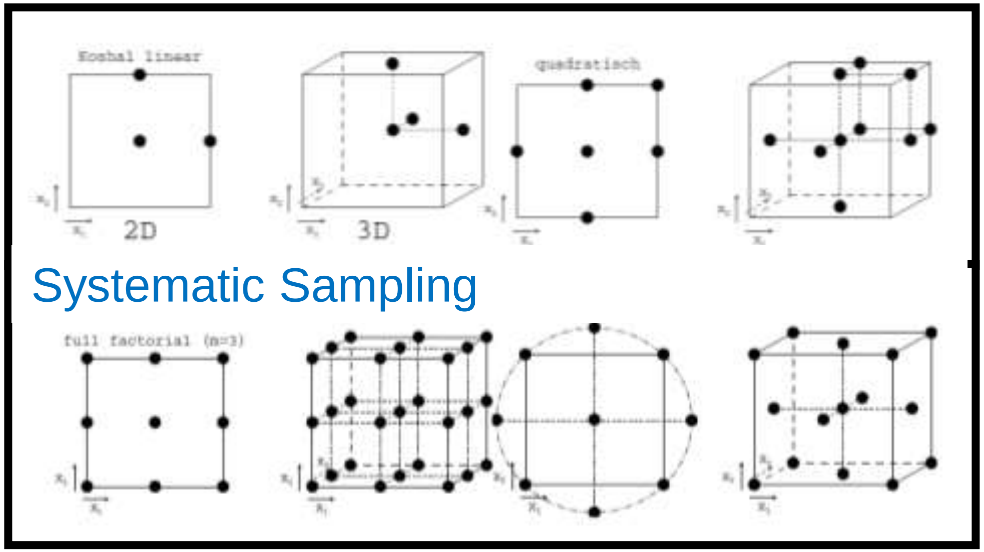
Optimization Strategy

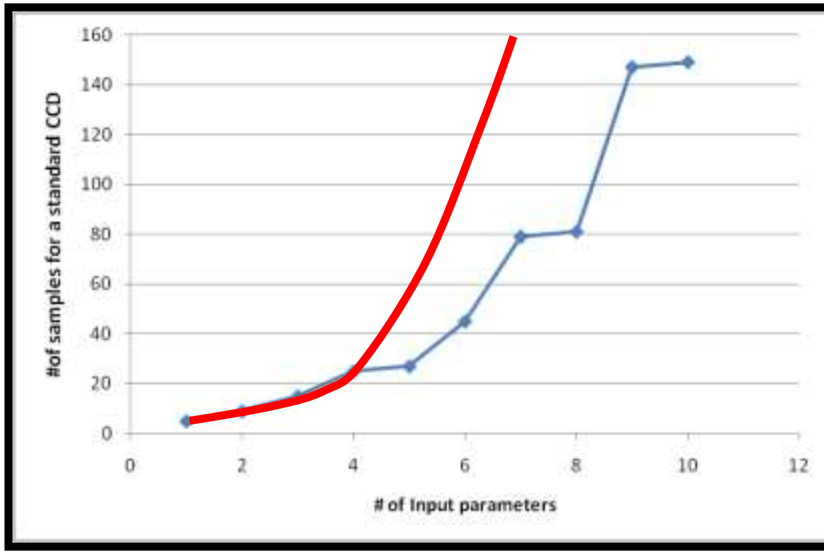
General Procedure:

- Design Optimization
  - Gradient Based
  - Generic
  - Evolutionary
  -

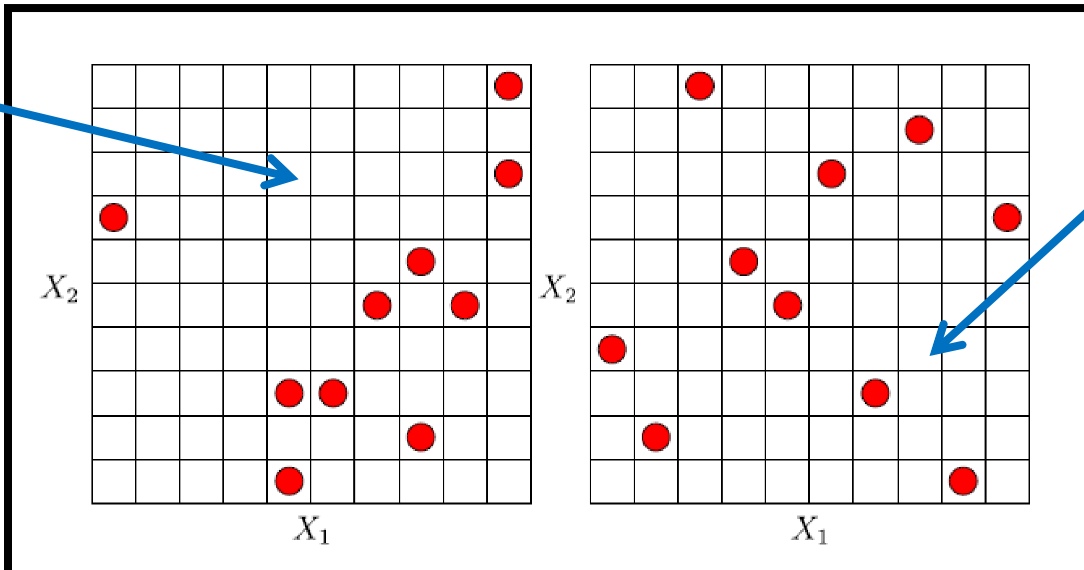
- Design of Experiments
  - Data Sampling
  - Detecting Correlations
  - Detecting Important Parameters
  - Parameter Space Reduction
  - Response Surface
- Design Optimization
  - …

Design of Experiments, Sampling





Monte Carlo Sampling



Latin Hypercube Sampling

"Random Correlation"

Low effort for high number of parameter

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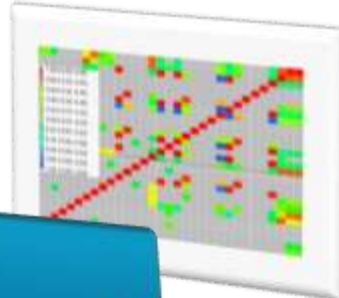
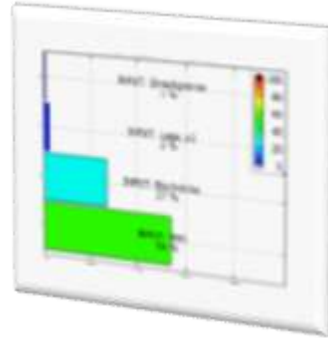
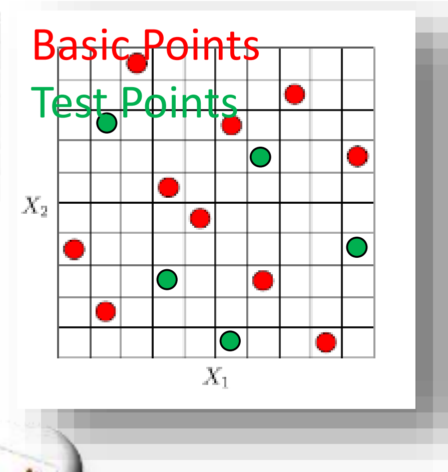
Meta-Model of Optimal Prognosis, MoP







Significance Filter

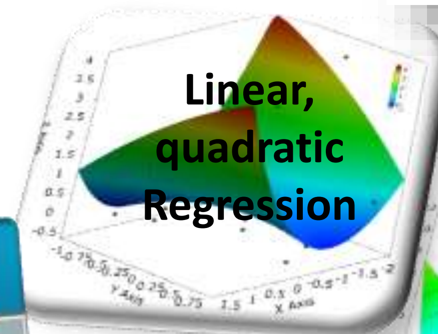
Importance Filter

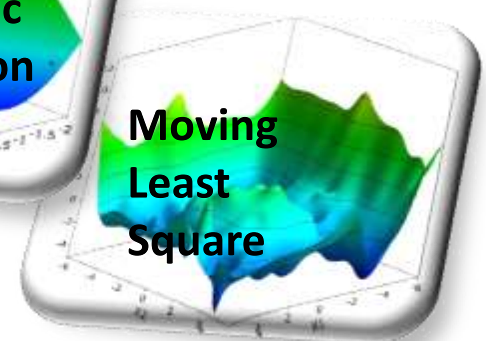
Test-Data Point Split

Response Surface

Coefficient of Prognosis

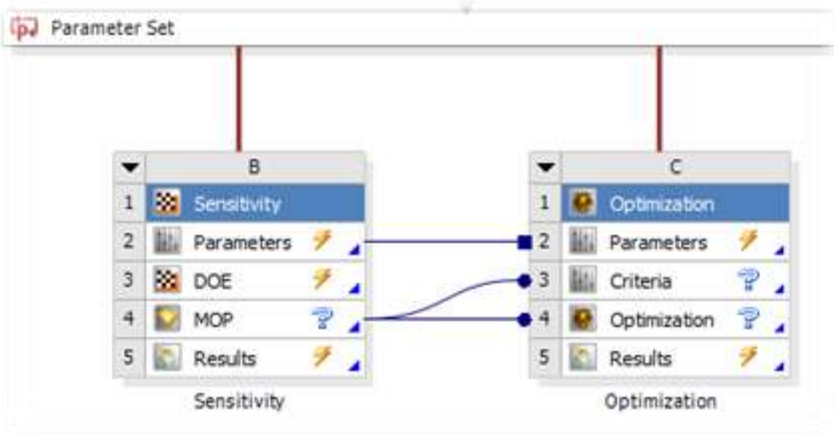
Variation of Filter Limits…



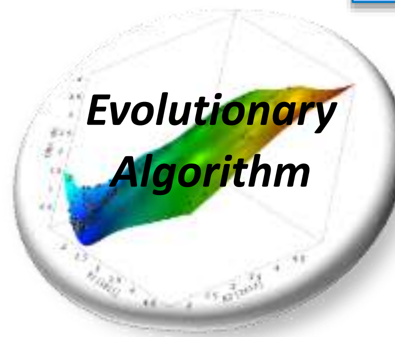


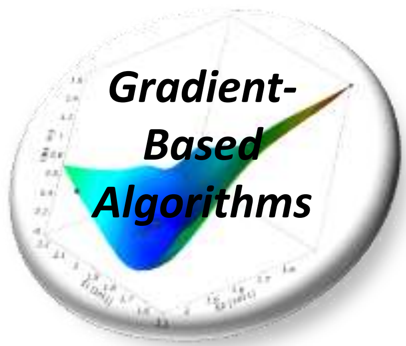
$$CoP = \left(\frac{E\left(Y \cdot \hat{Y}\right)}{\sigma_Y \cdot \sigma_{\hat{Y}}} \right)^2 = \left(\frac{\sum_{k=1}^{N} \left(y^{(k)} - \mu_y \right) \cdot \left(\hat{y}^{(k)} - \mu_{\hat{y}} \right)}{\left(N - 1 \right) \cdot \sigma_Y \cdot \sigma_{\hat{Y}}} \right)^2$$

Design Optimization

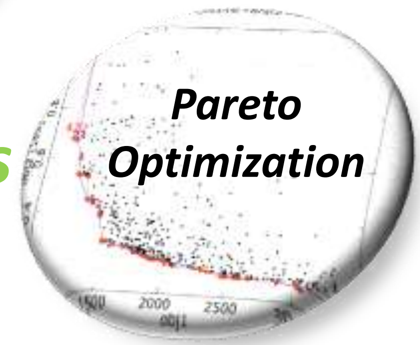


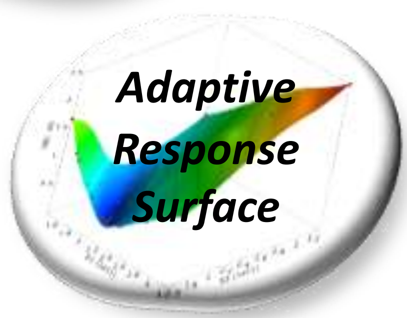
Optimization Algorithms:

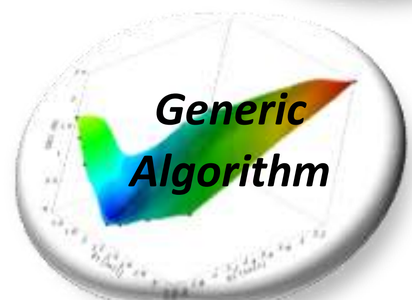




Which one is the best?

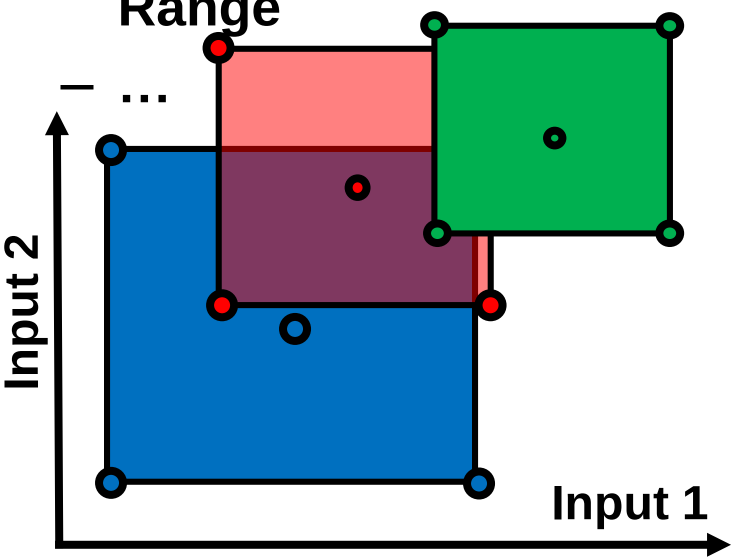


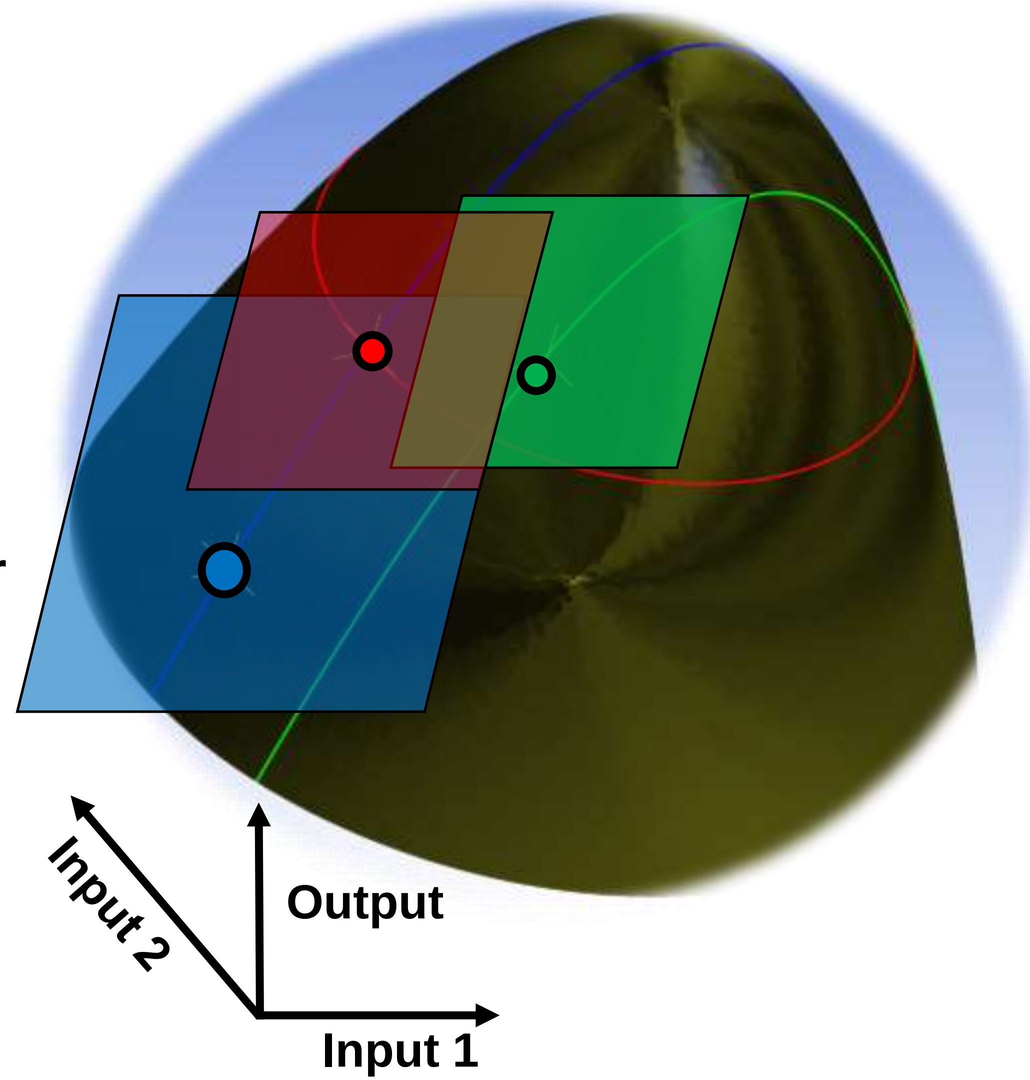




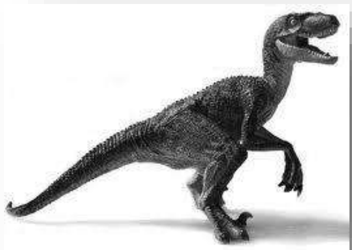
Adaptive Response Surface Method

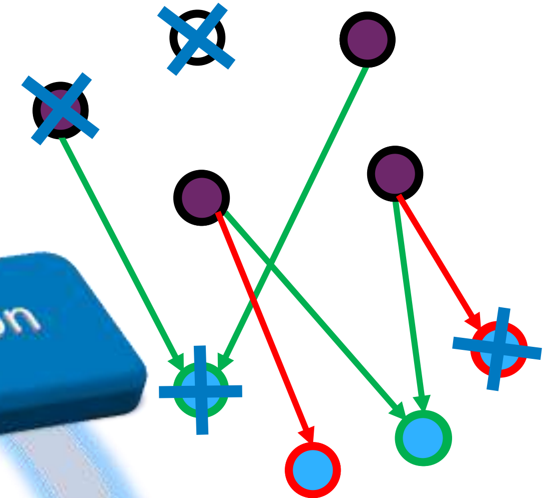
- **Start Point**
- **Initial Sample**
  - **Approximated Response Surface**
  - **Best Point**
  - **New Sample with smaller Range**
  - **…**





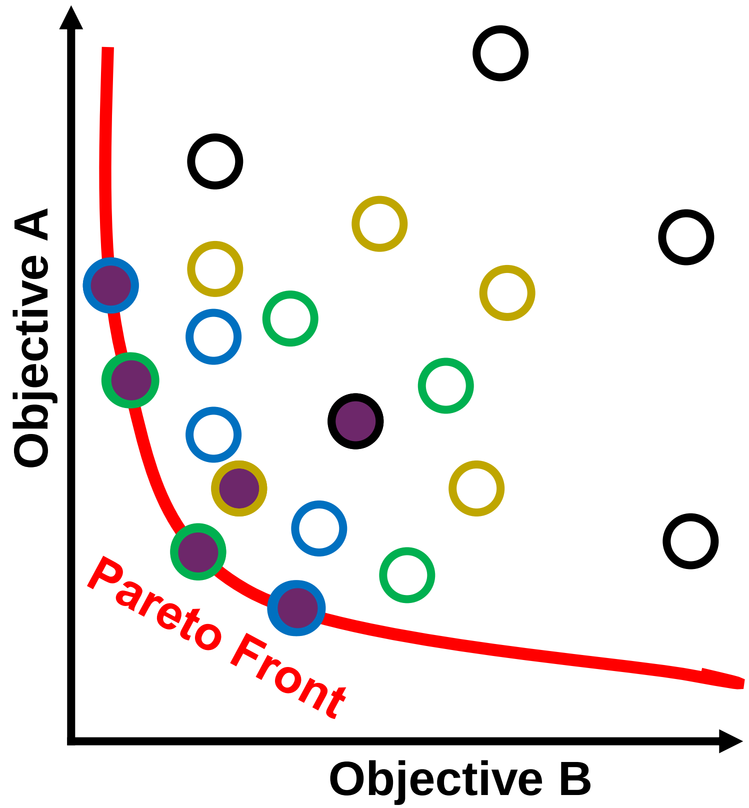
Evolutionary Algorithms





Pareto Optimization

- **Initial Generation**
  - Select best
- **Second Generation**
  - Select best
- **Third Generation**
  - Select best
- **Fourth Generation**
  - Select best
- …



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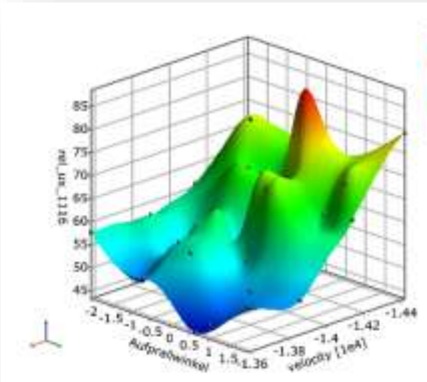
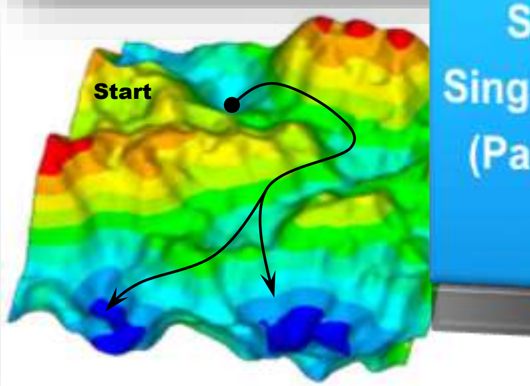
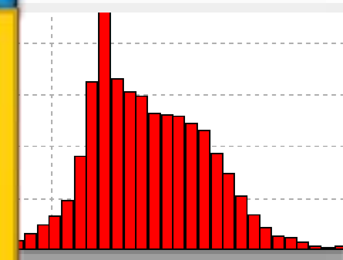
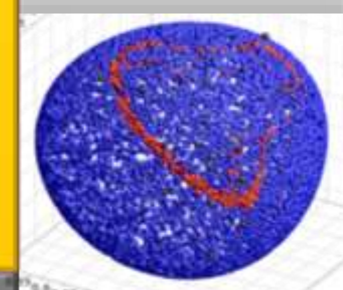
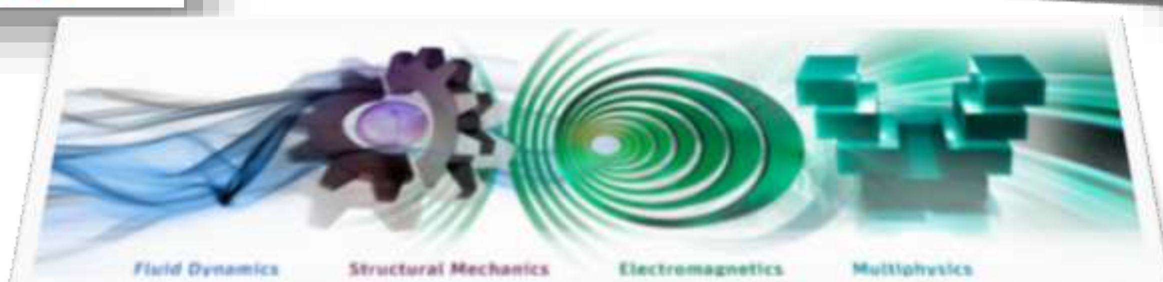


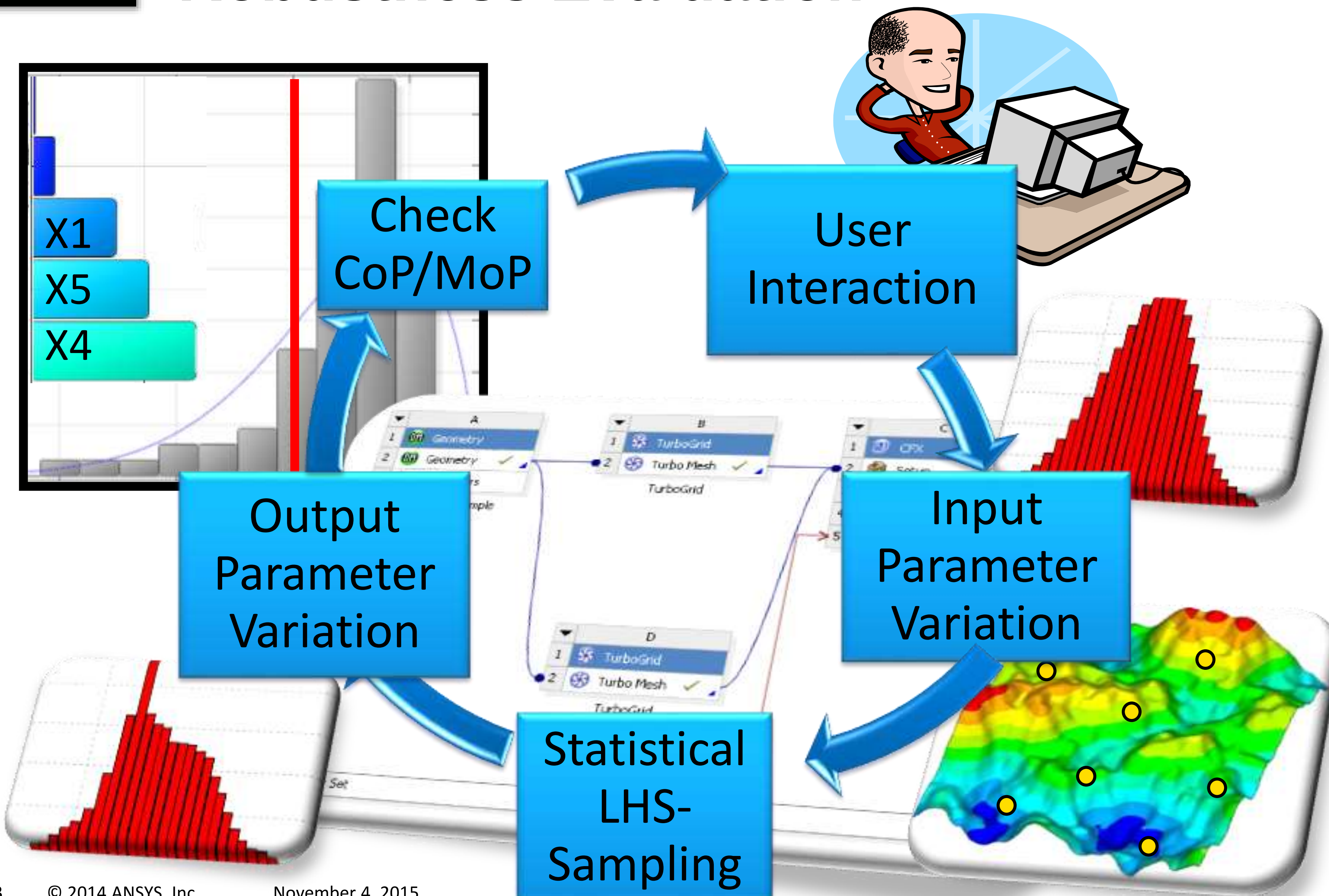








Robustness Evaluation



Outline

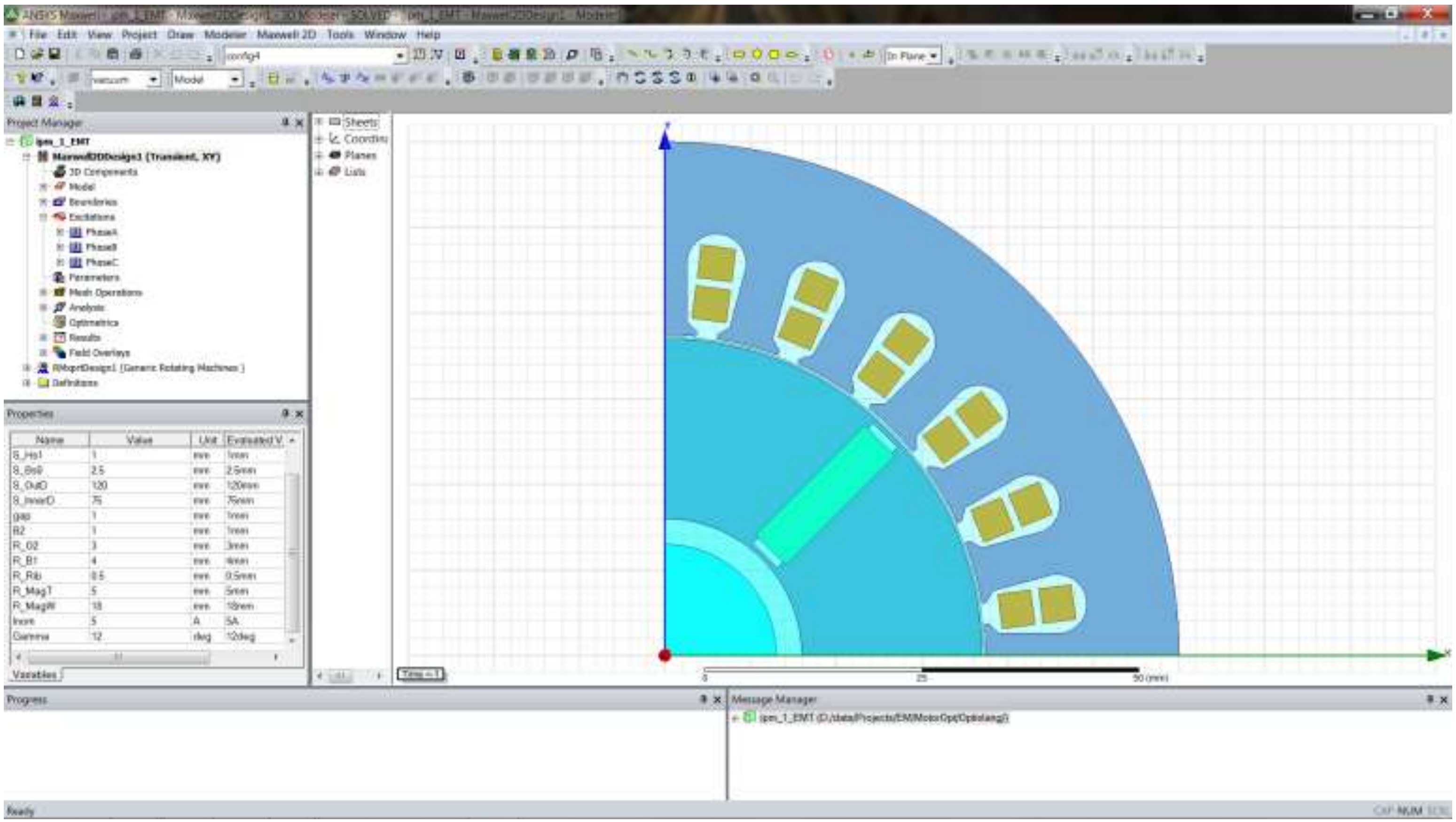
Challenges in Virtual Prototyping

Methods in optiSLang

Example Application

Maxwell 2D Setup

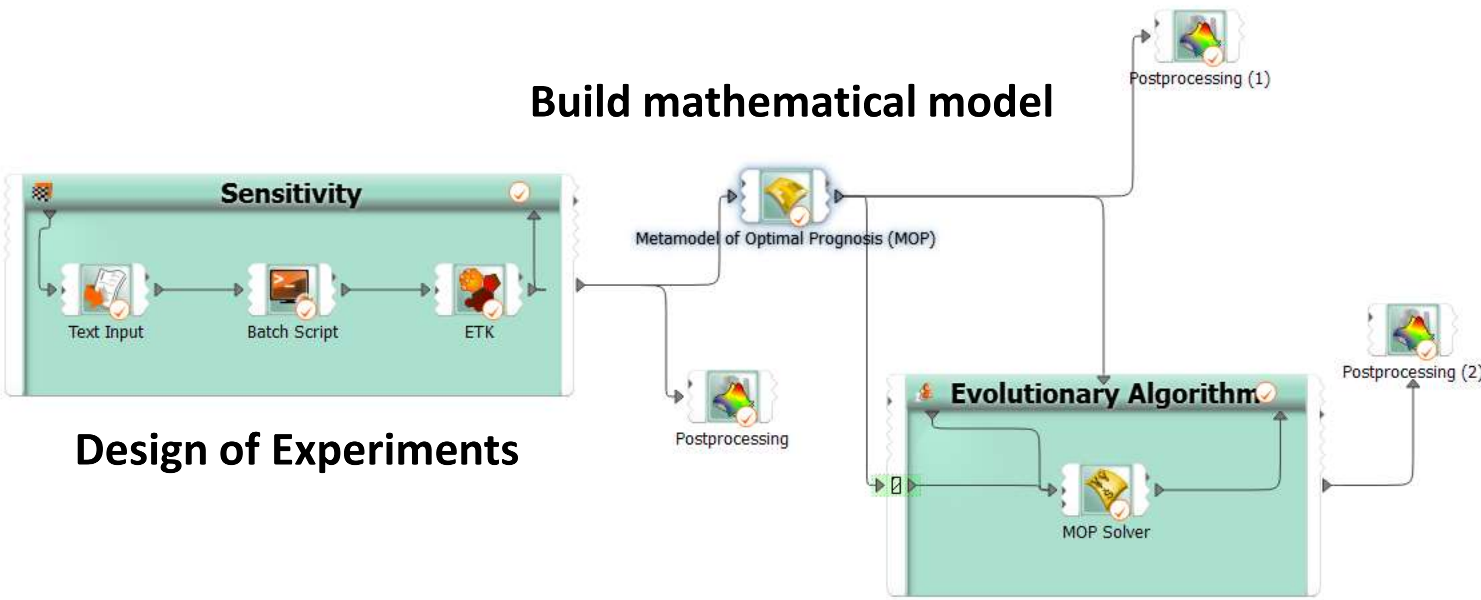
We need a valid setup including Electrical Machine Toolkit UDO's



Setup in OptiSlang

Use graphical description of dataflow in OptiSlang

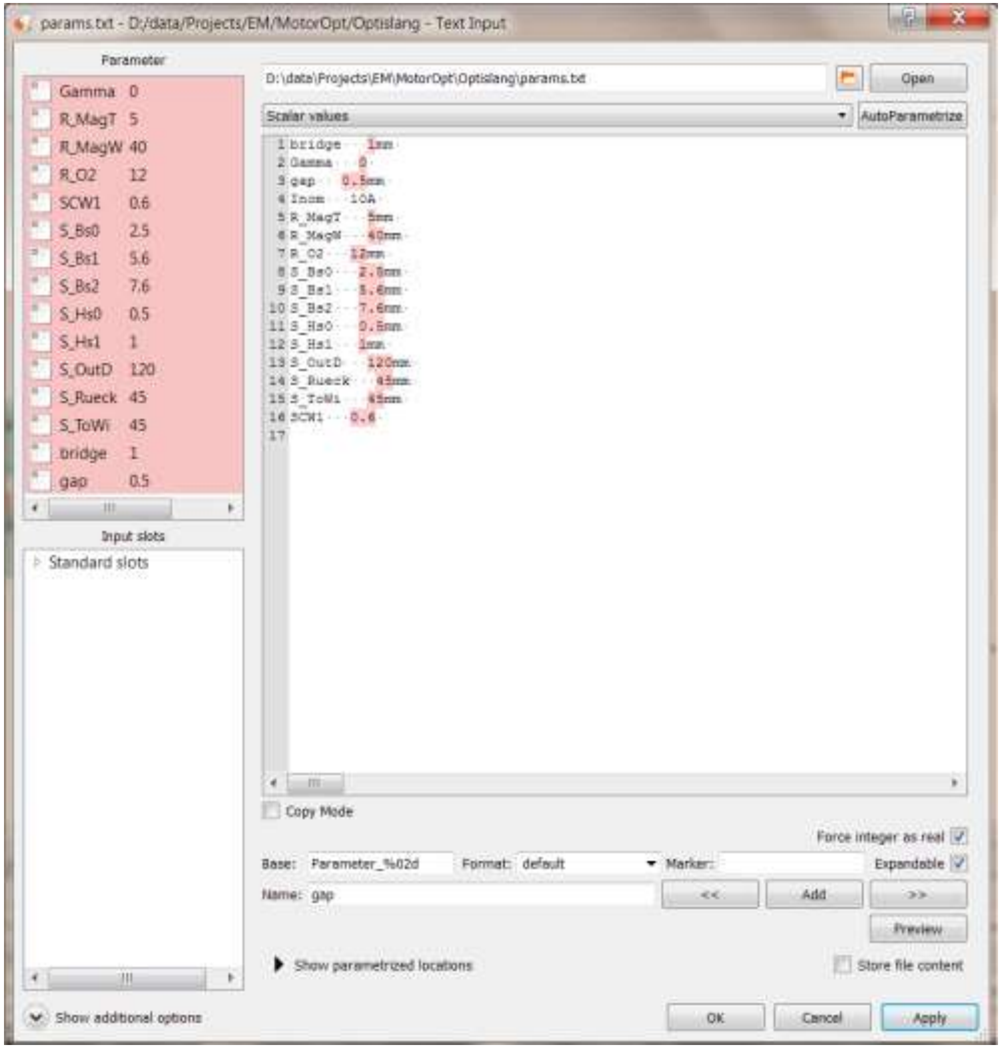
Build mathematical model



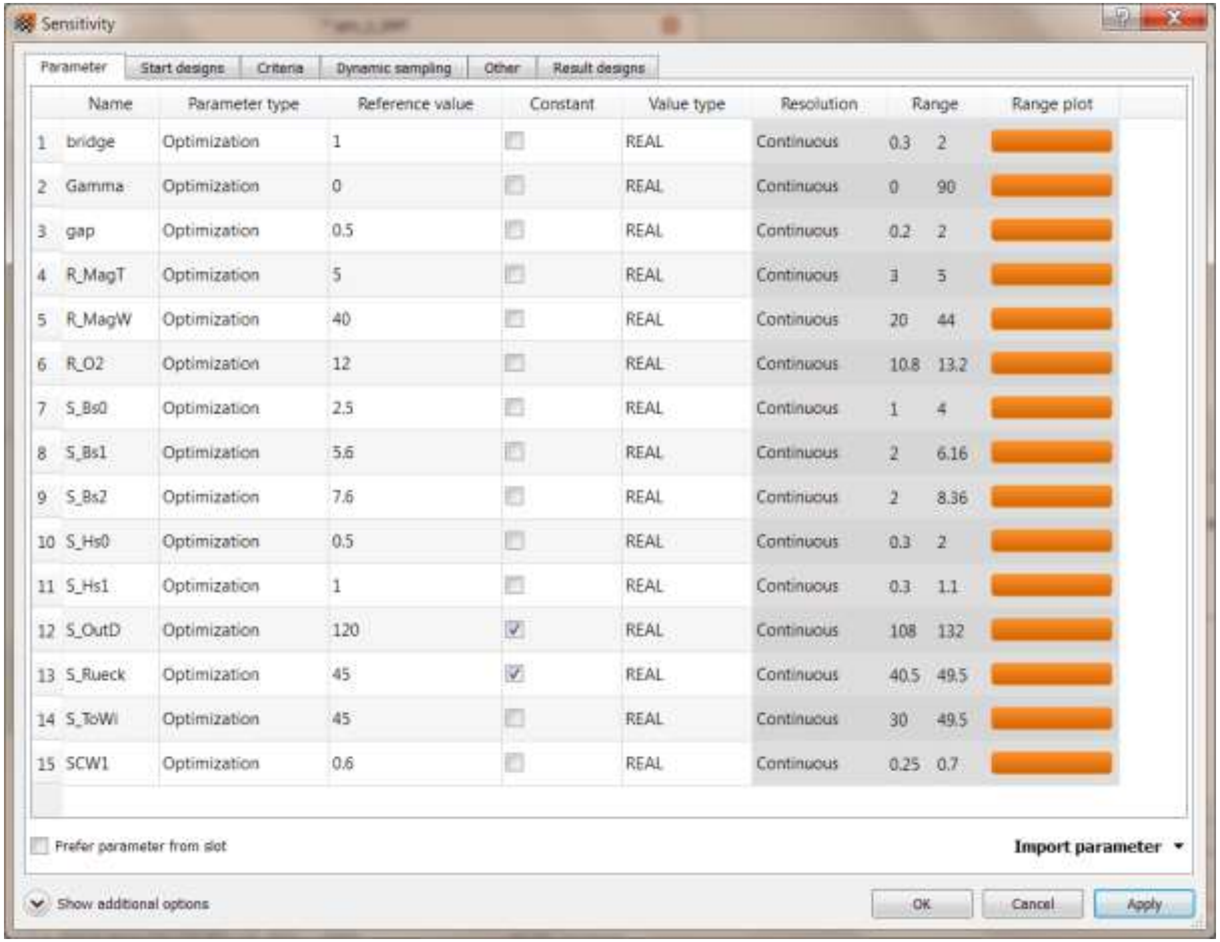
Design of Experiments

Optimisation

Use script to dump out all parameters

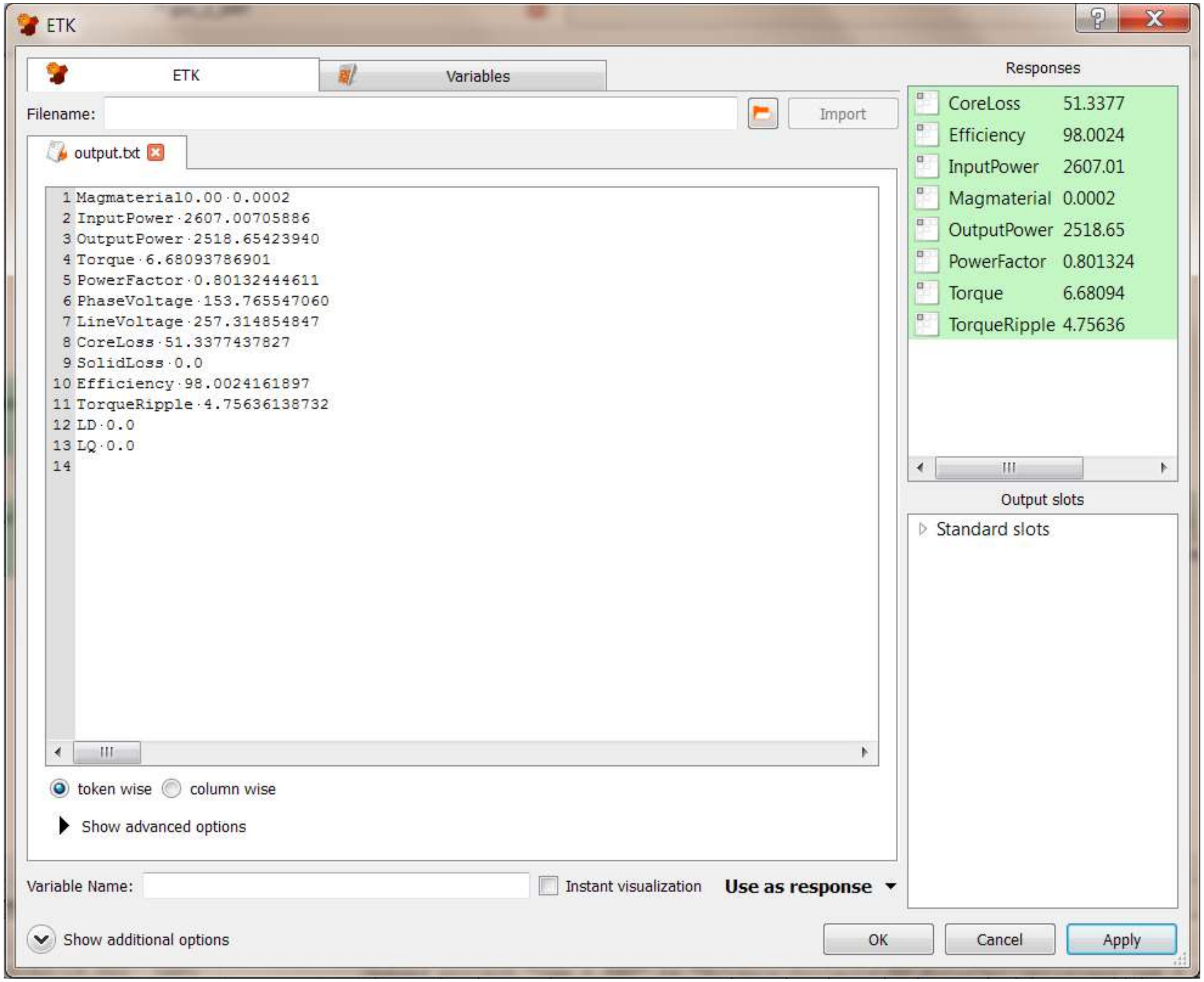


Define min and max values for parameters

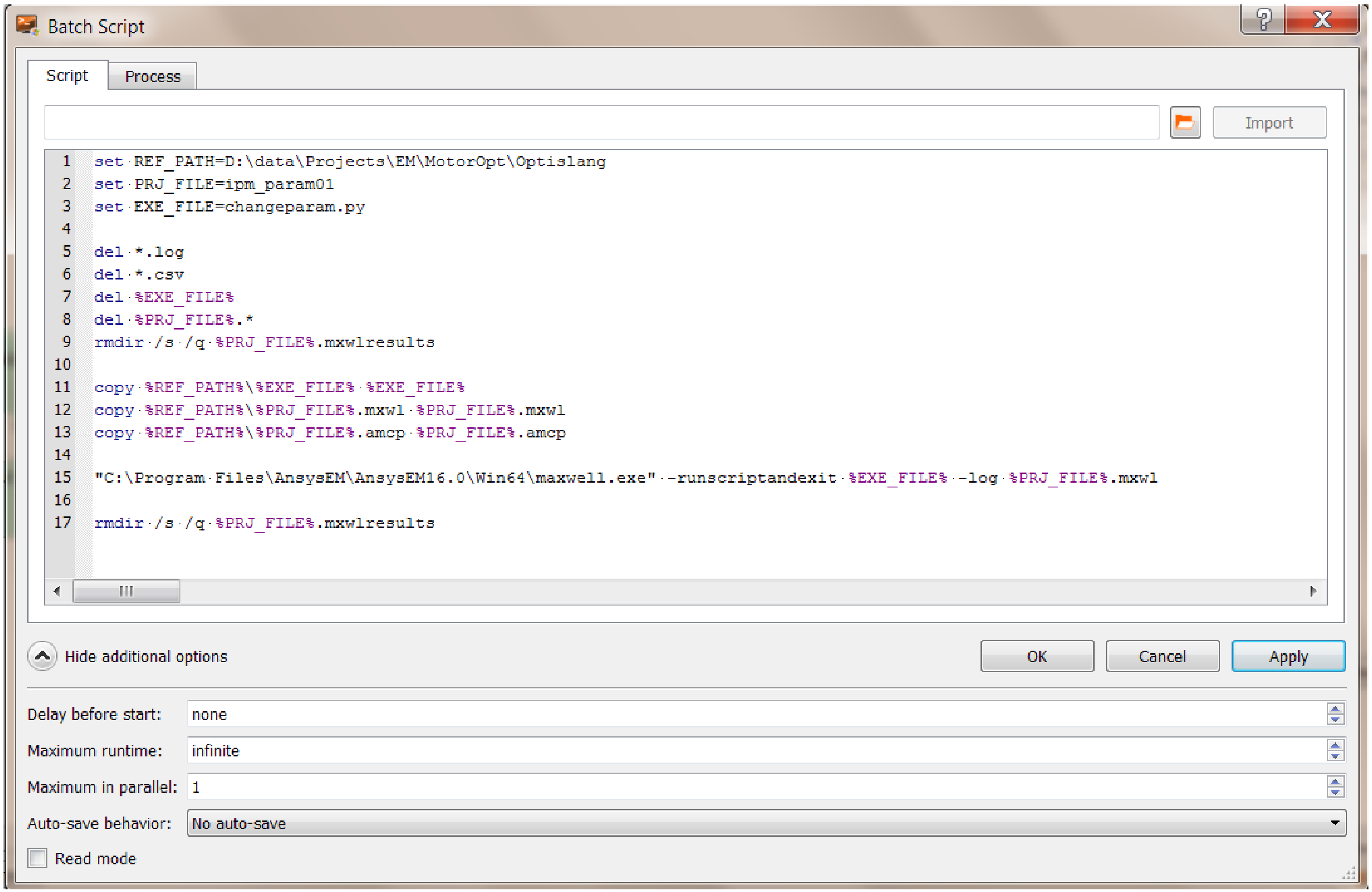


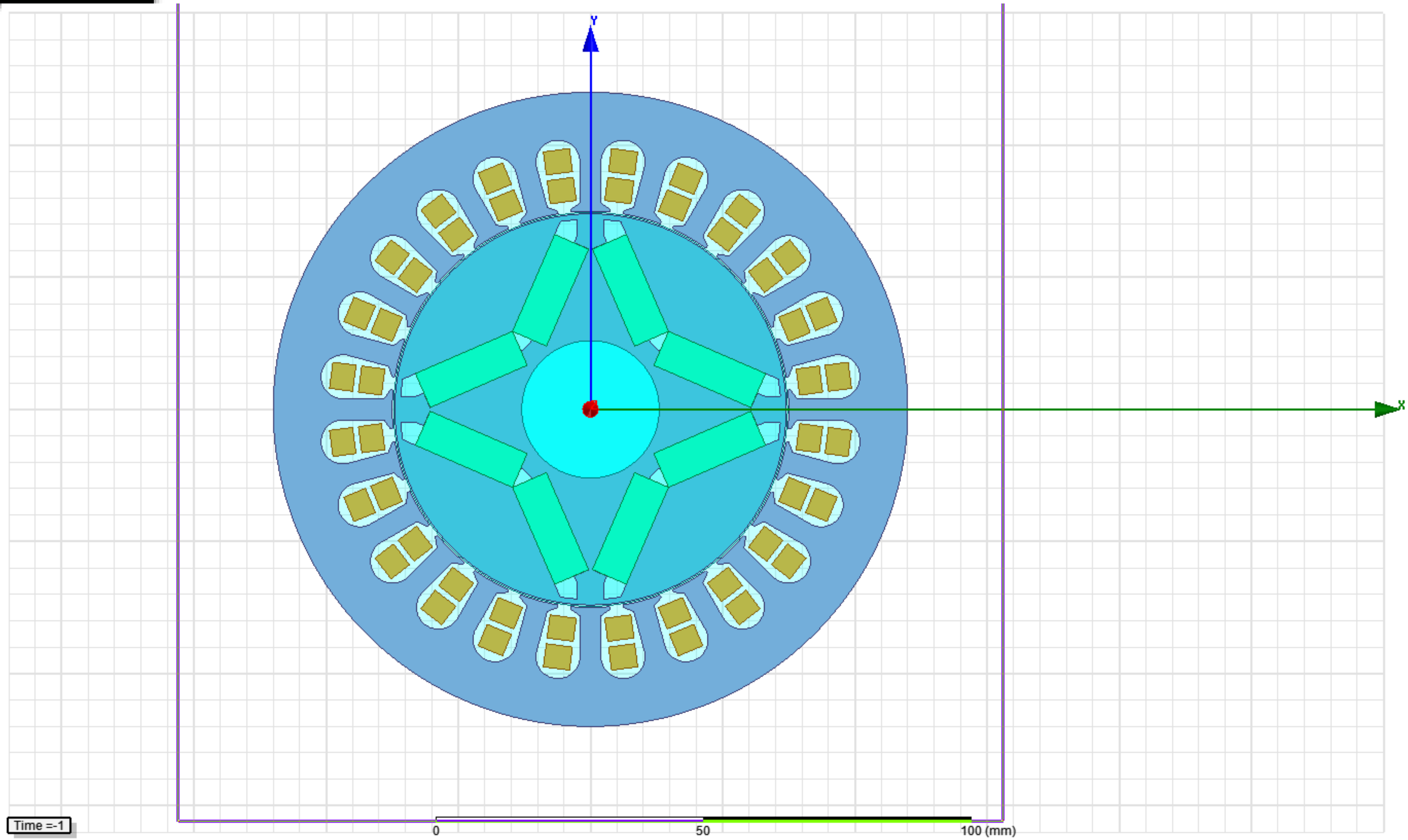
	Name	Parameter type	Reference value	Constant	Value type	Resolution	Range		Range plot
1	bridge	Optimization	1	☐	REAL	Continuous	0.3	2	
2	Gamma	Optimization	0	☐	REAL	Continuous	0	90	
3	gap	Optimization	0.5	☐	REAL	Continuous	0.2	2	
4	R_MagT	Optimization	5	☐	REAL	Continuous	3	5	
5	R_MagW	Optimization	40	☐	REAL	Continuous	20	44	
6	R_O2	Optimization	12	☐	REAL	Continuous	10.8	13.2	
7	S_Bs0	Optimization	2.5	☐	REAL	Continuous	1	4	
8	S_Bs1	Optimization	5.6	☐	REAL	Continuous	2	6.16	
9	S_Bs2	Optimization	7.6	☐	REAL	Continuous	2	8.36	
10	S_Hs0	Optimization	0.5	☐	REAL	Continuous	0.3	2	
11	S_Hs1	Optimization	1	☐	REAL	Continuous	0.3	1.1	
12	S_OutD	Optimization	120	☑	REAL	Continuous	108	132	
13	S_Rueck	Optimization	45	☑	REAL	Continuous	40.5	49.5	
14	S_ToWi	Optimization	45	☐	REAL	Continuous	30	49.5	
15	SCW1	Optimization	0.6	☐	REAL	Continuous	0.25	0.7	

Define Outputs



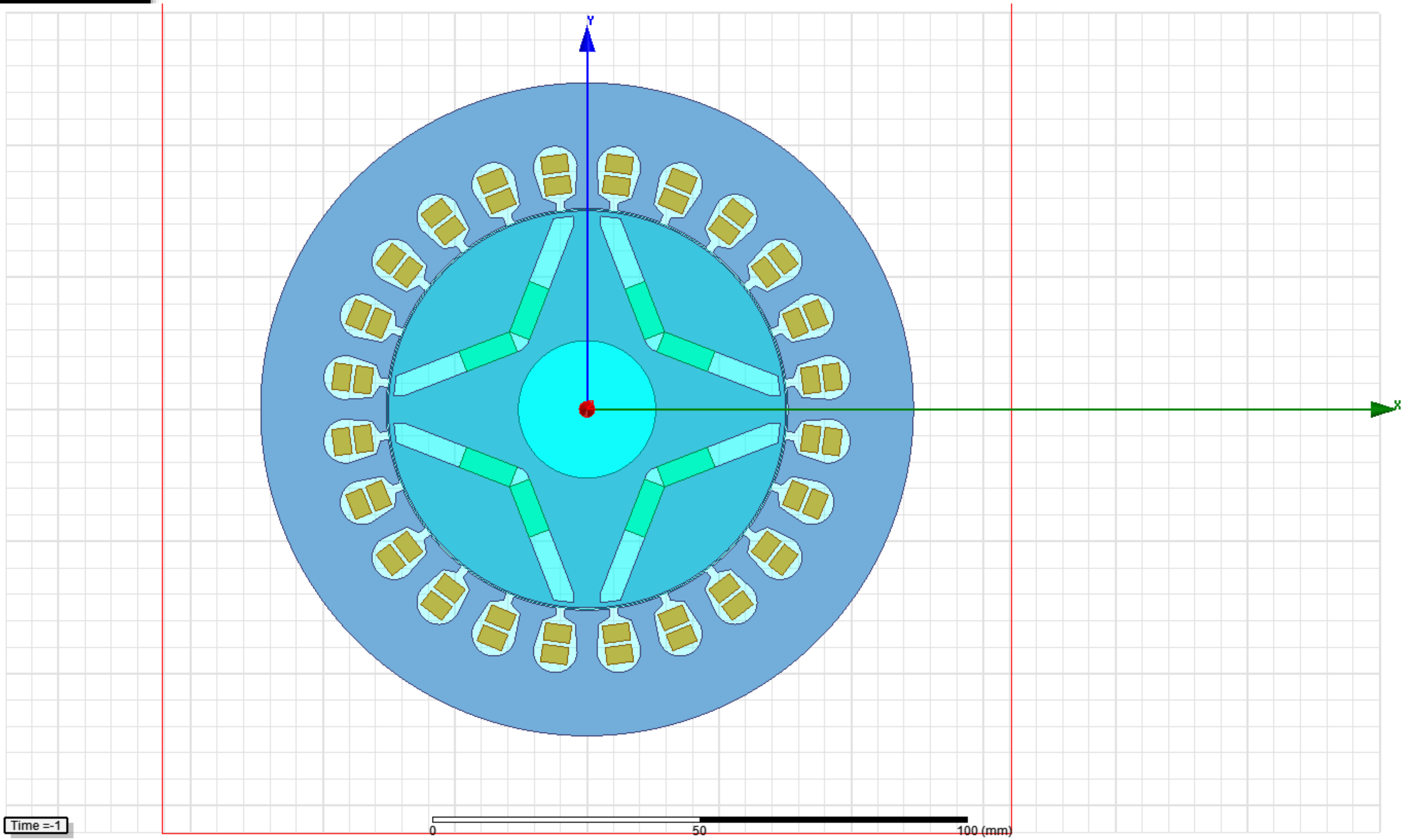
Edit script to call Maxwell

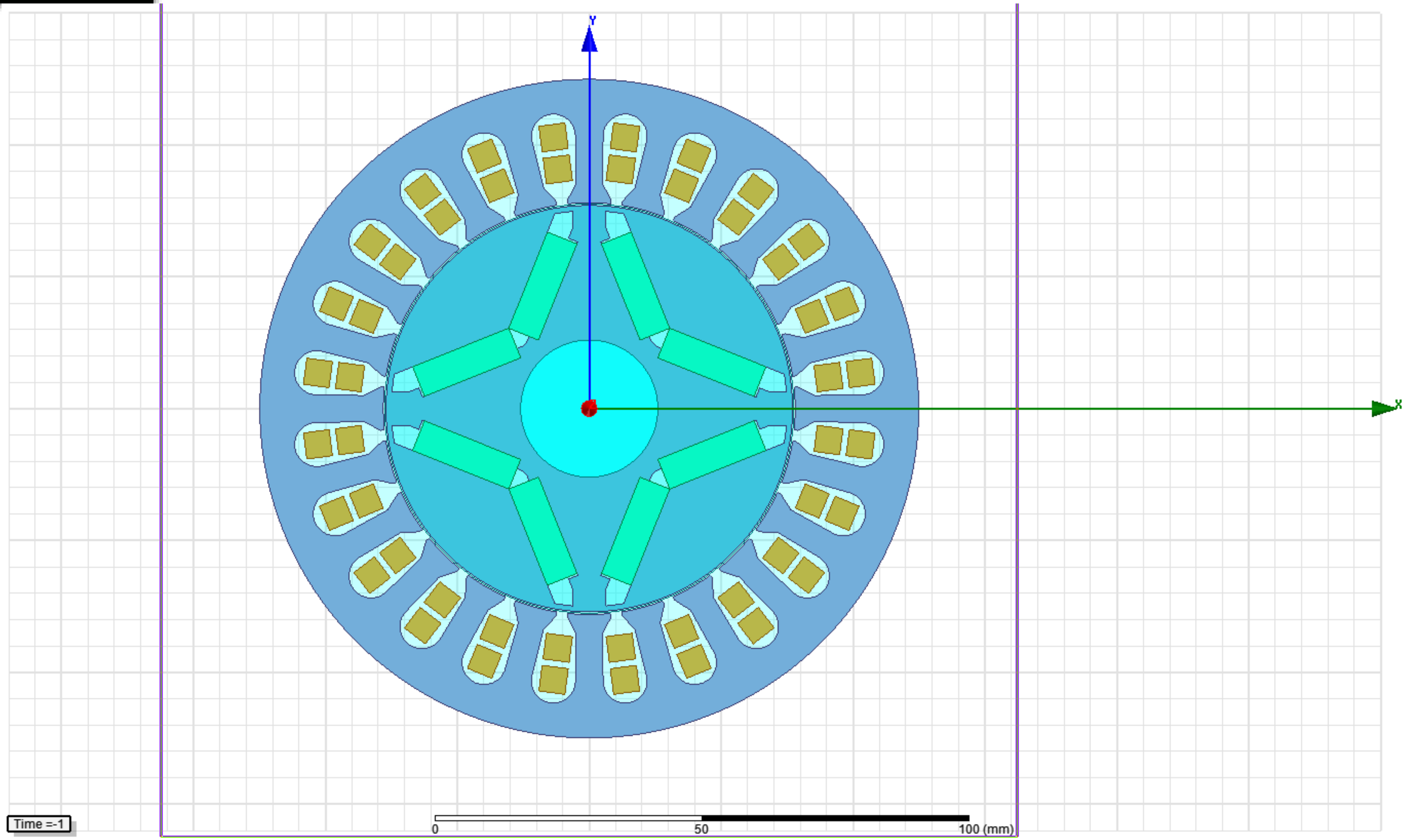




Y
X
Time =-1
0
50
100 (mm)

ANSYS

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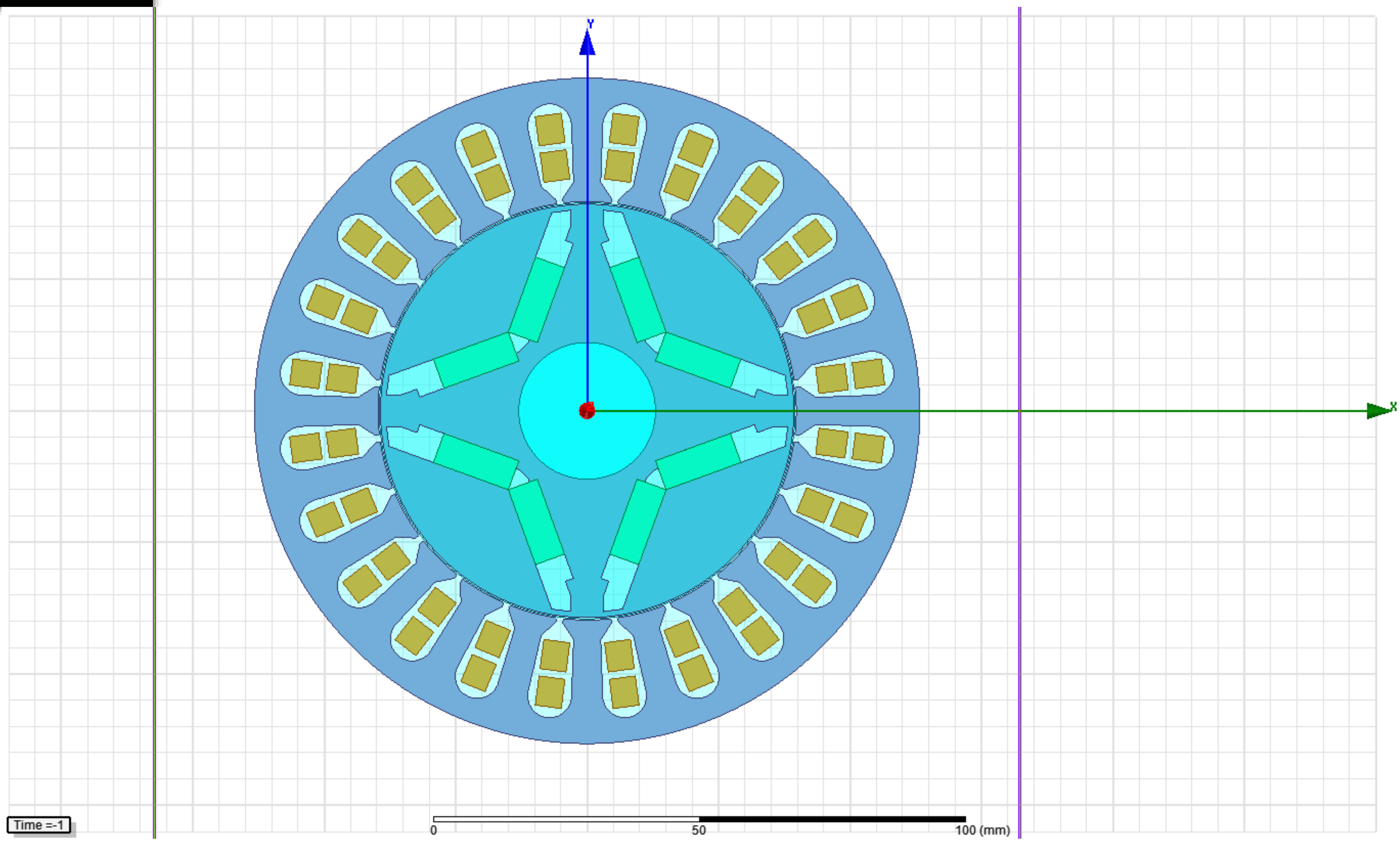
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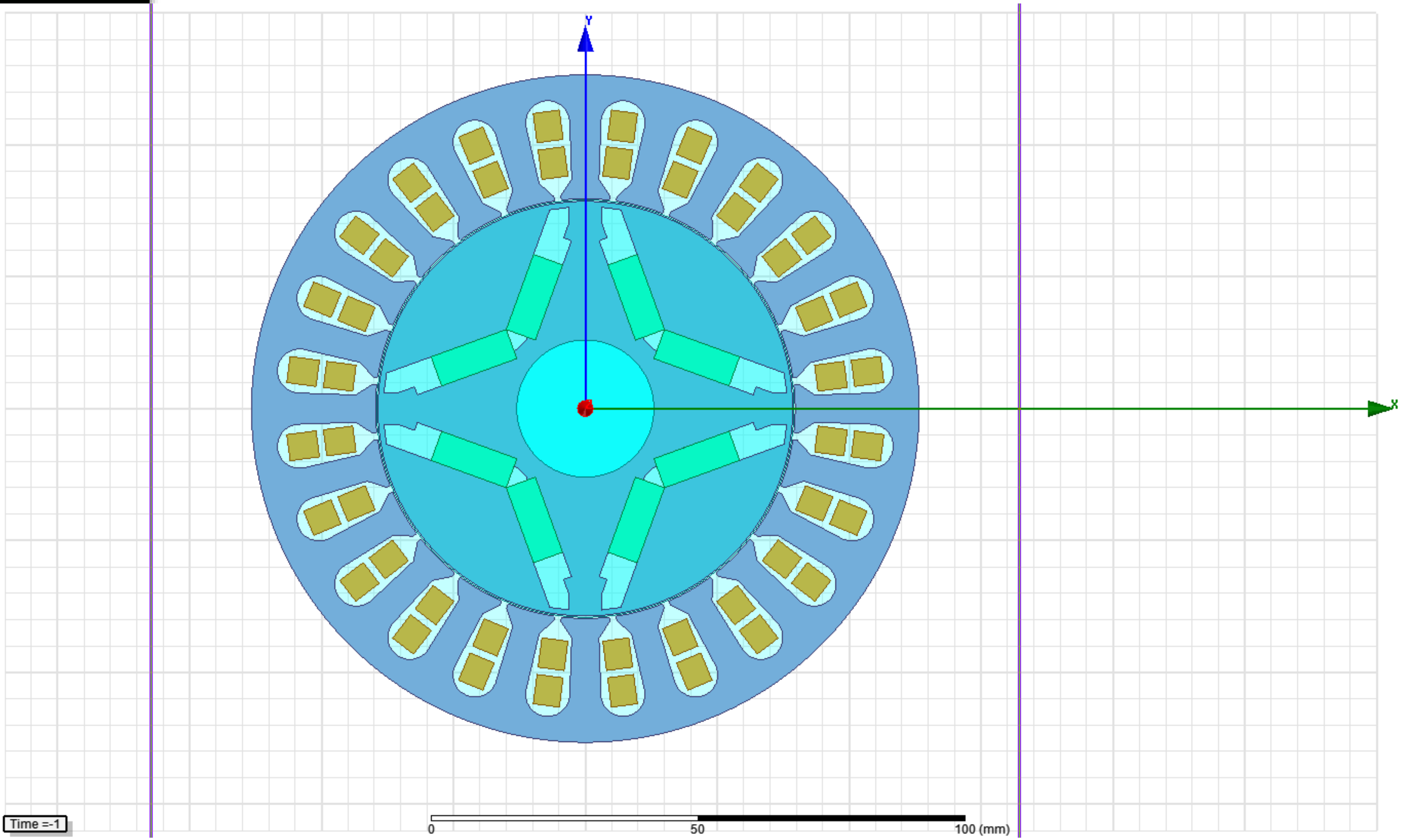
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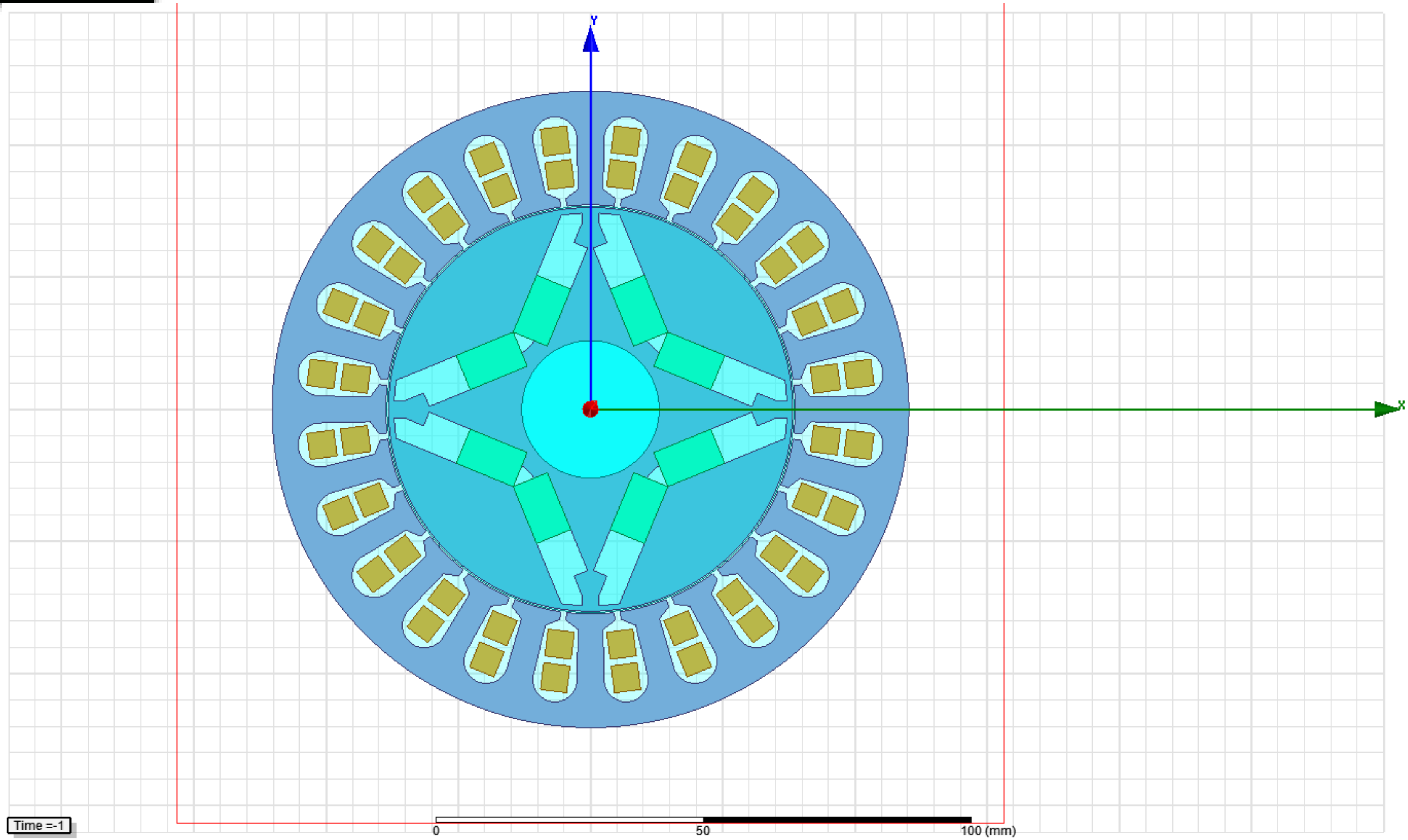
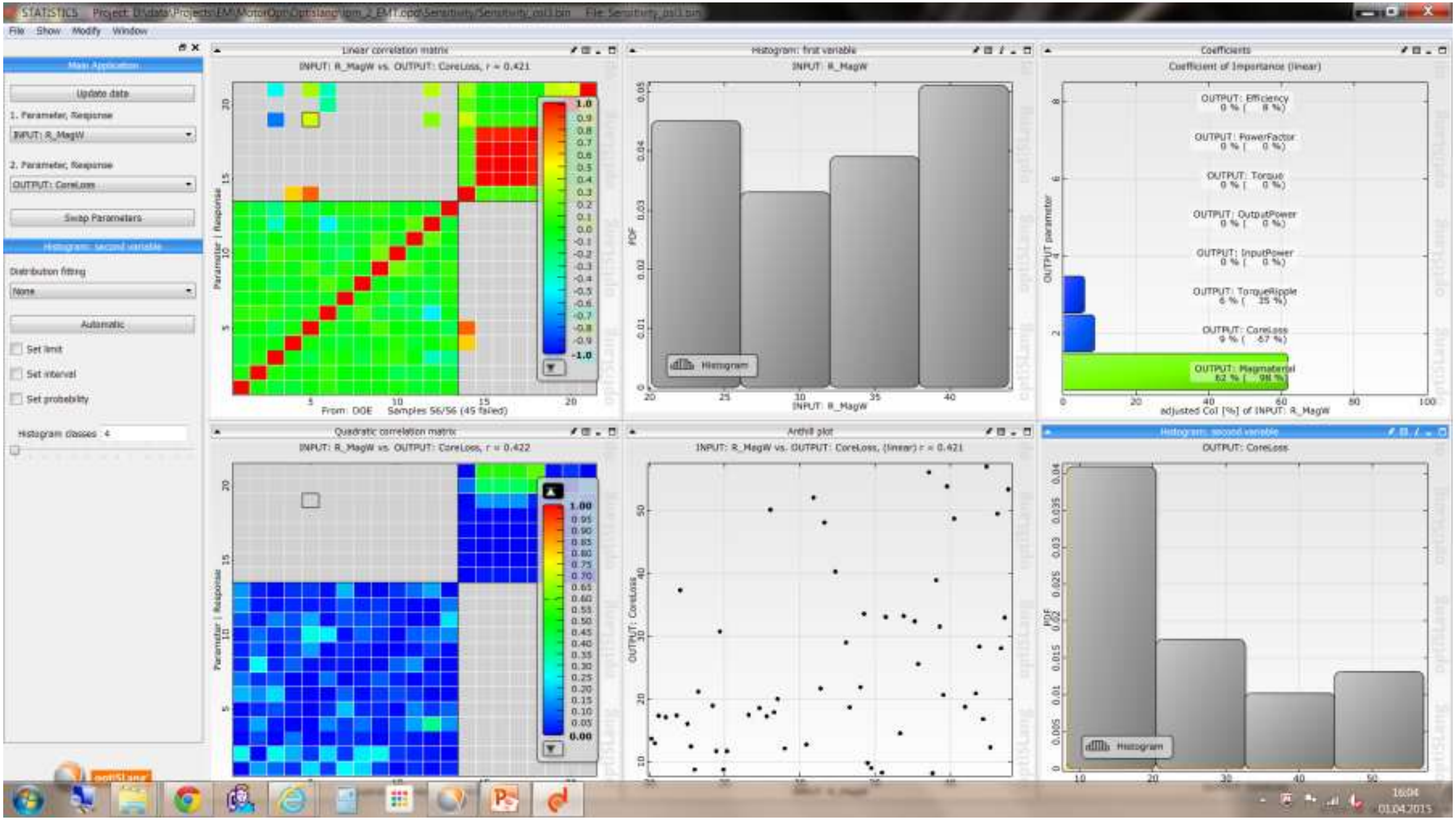
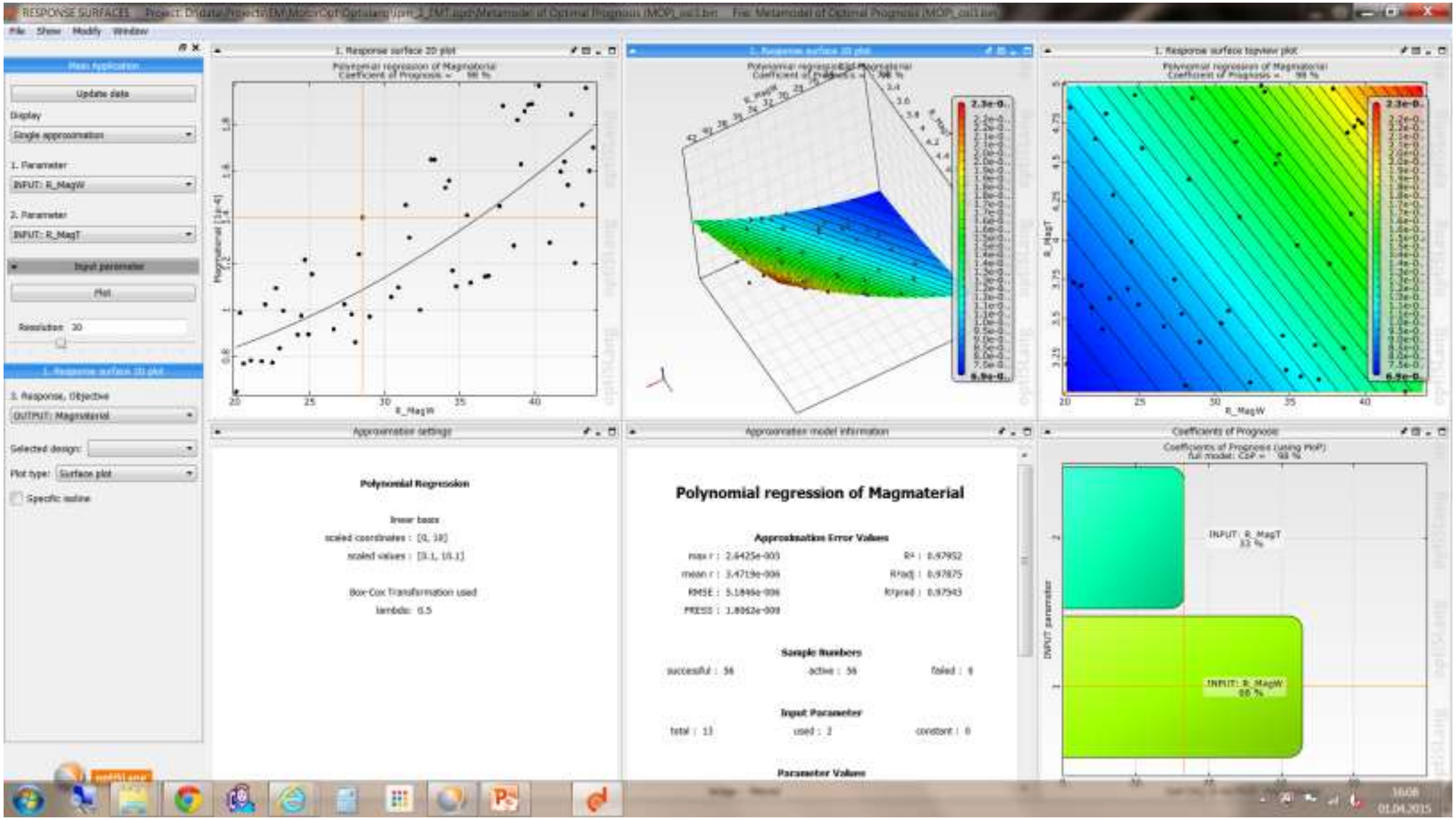

Y
X
Time =-1
0
50
100 (mm)

Run Sensitivity

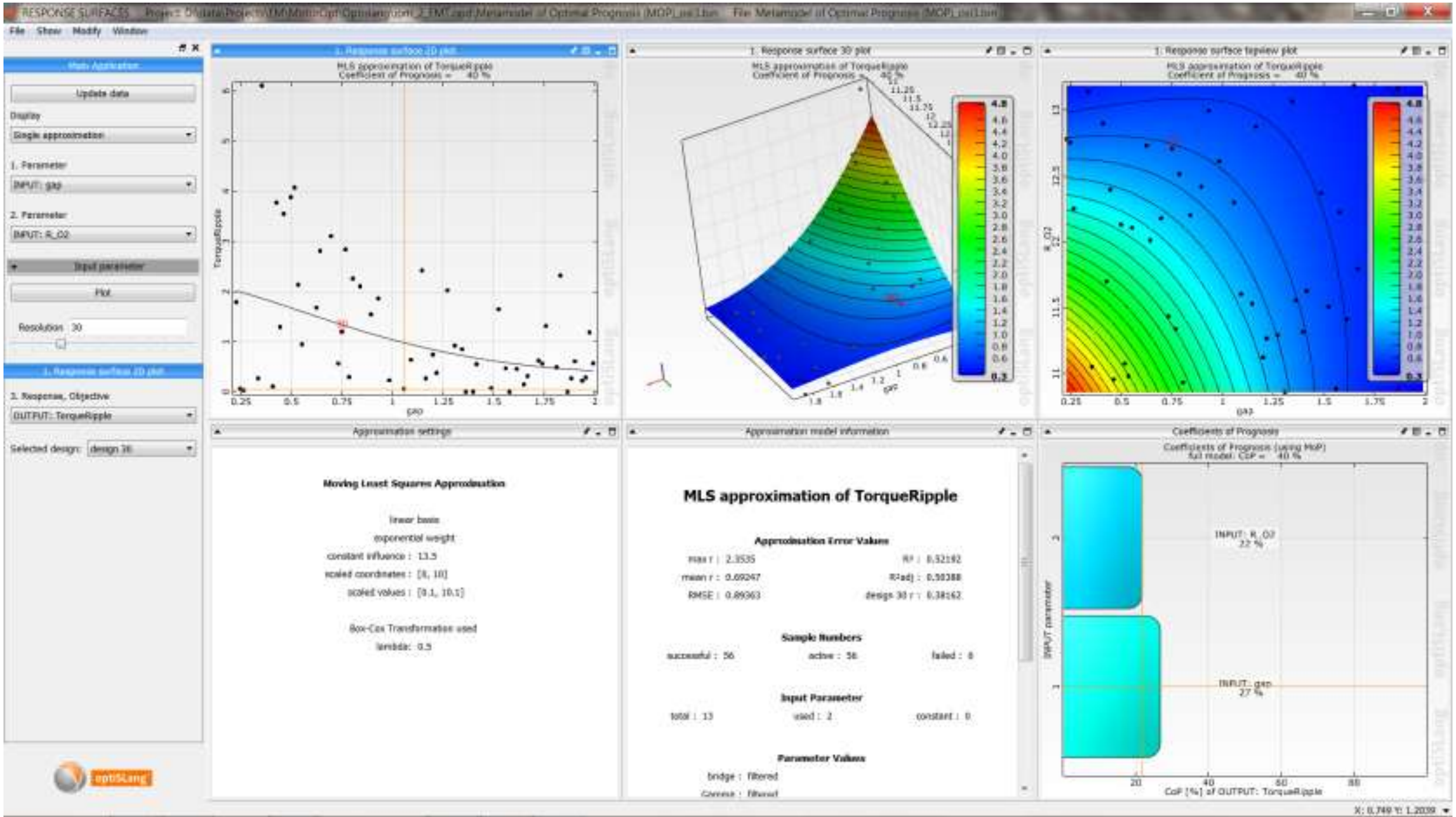


  November 4, 2015

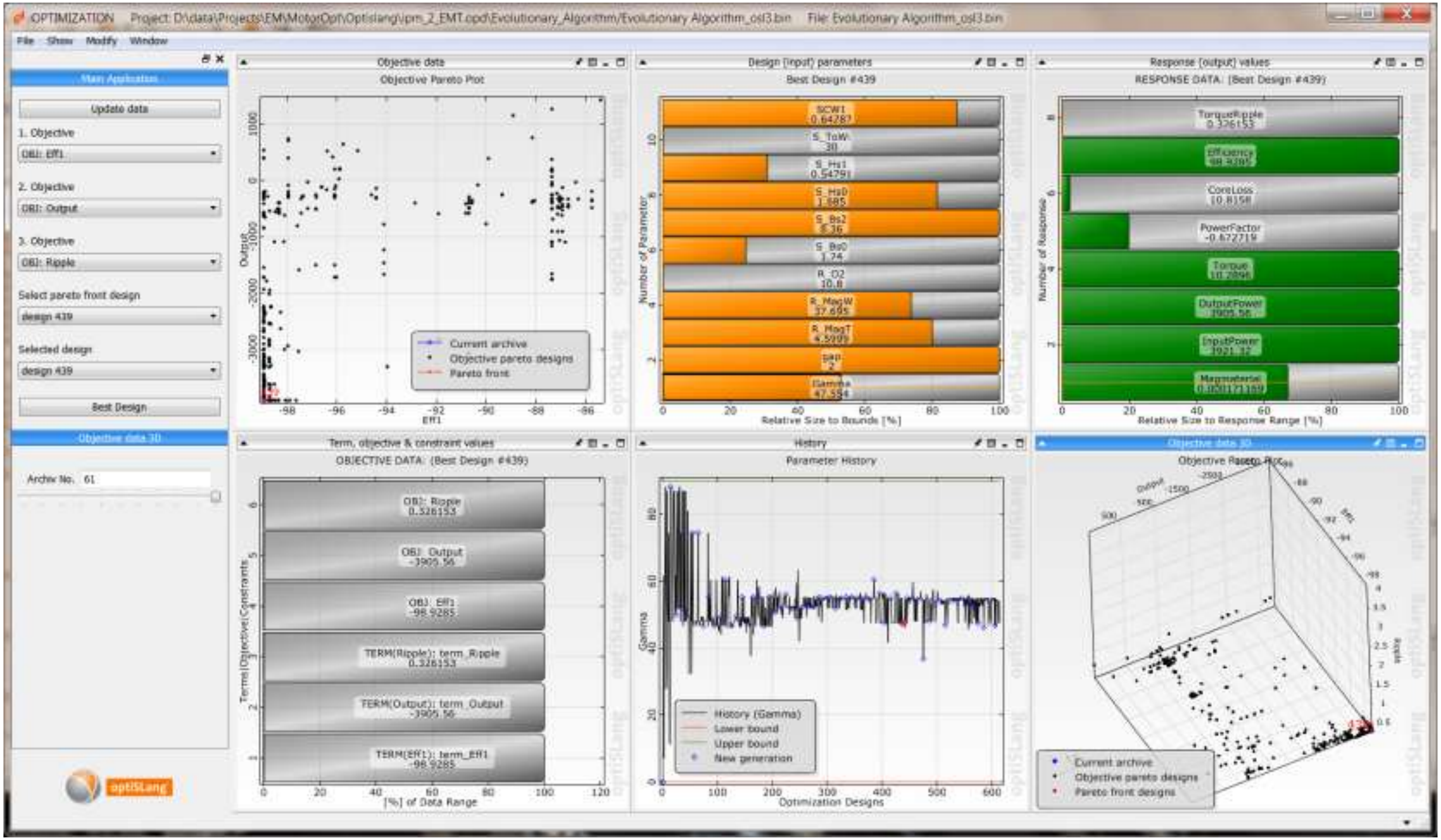
Build a Metamodel



Metamodel Data

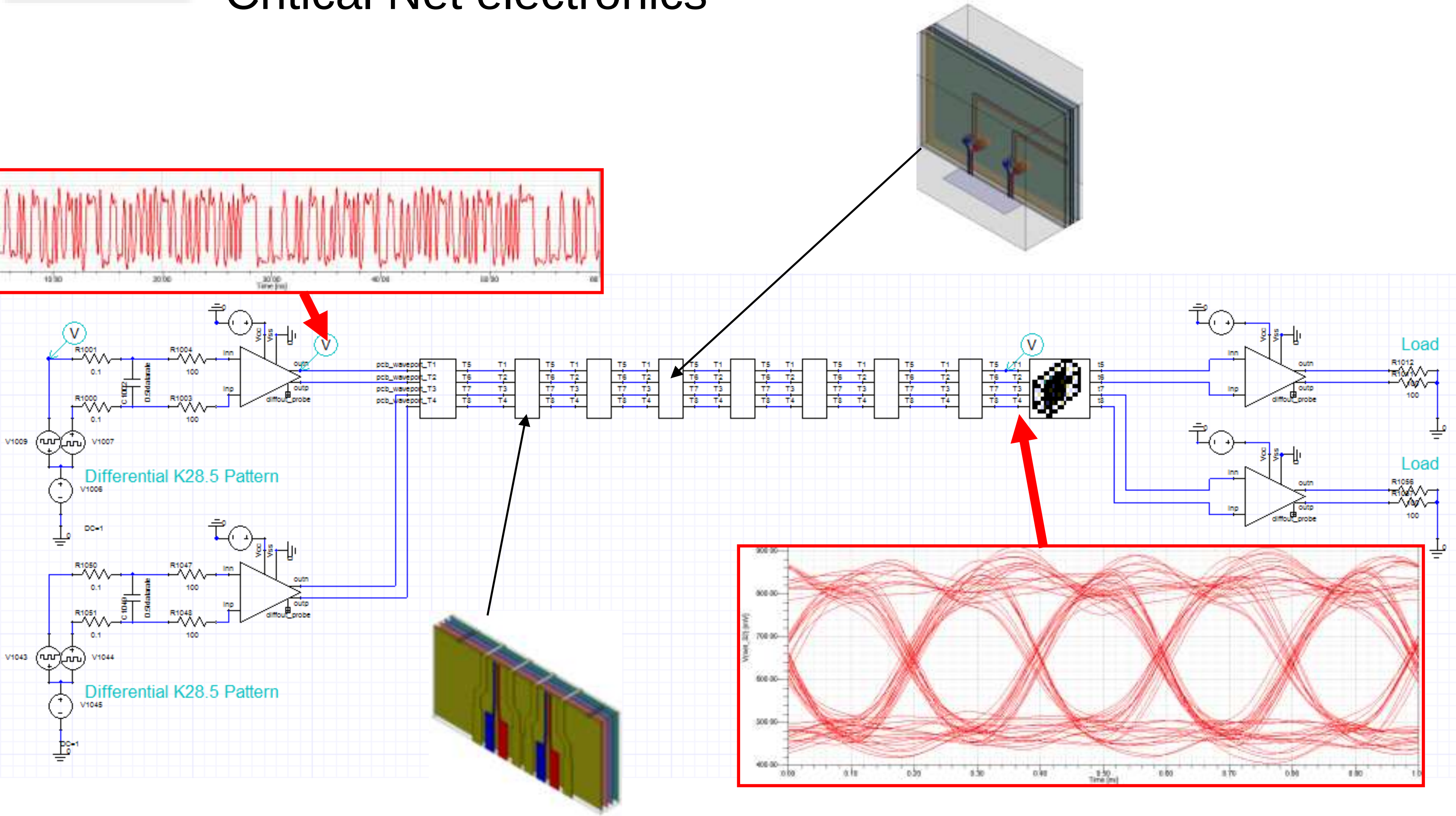


Run Optimizer

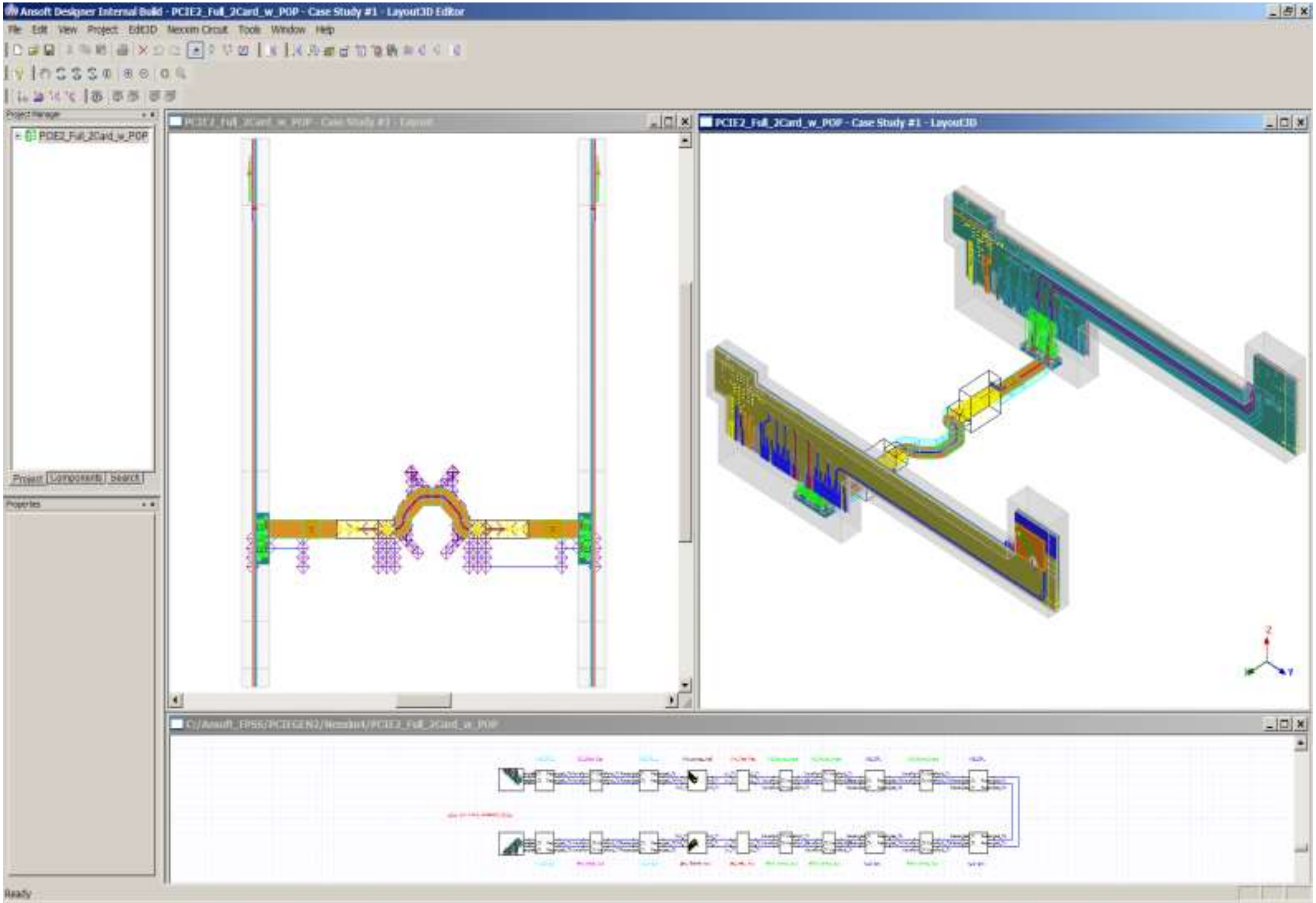


Time Domain Verification

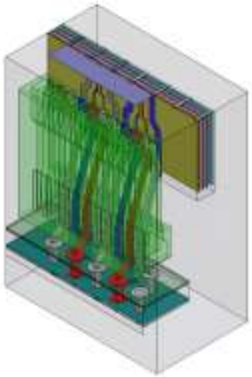
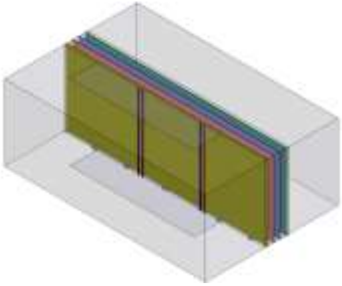
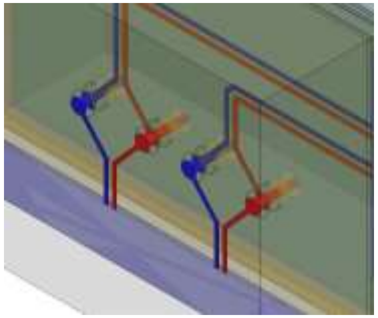
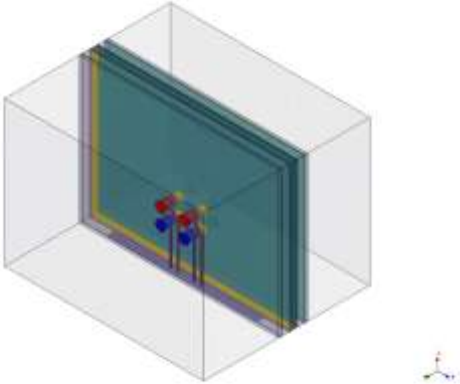
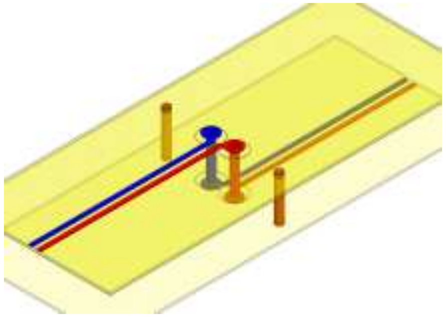
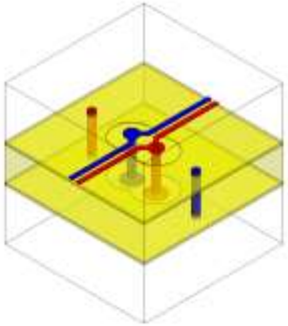
Critical Net electronics



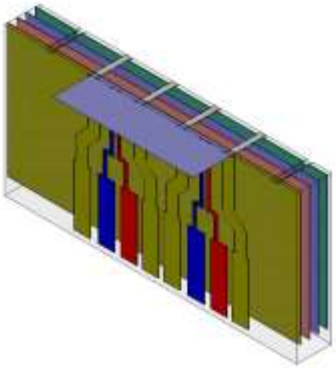
PCB Transmission Channels

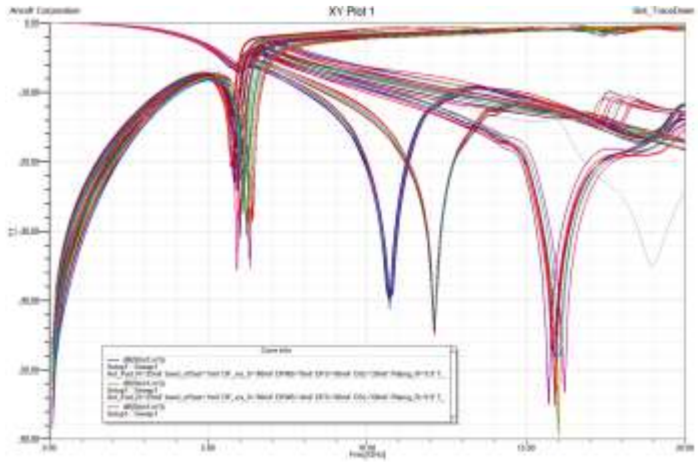


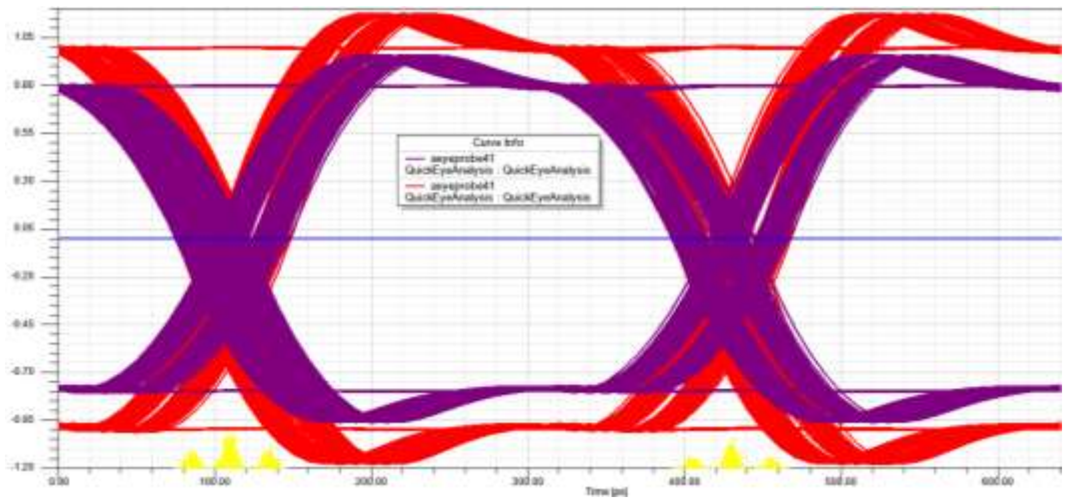
PCB Structures

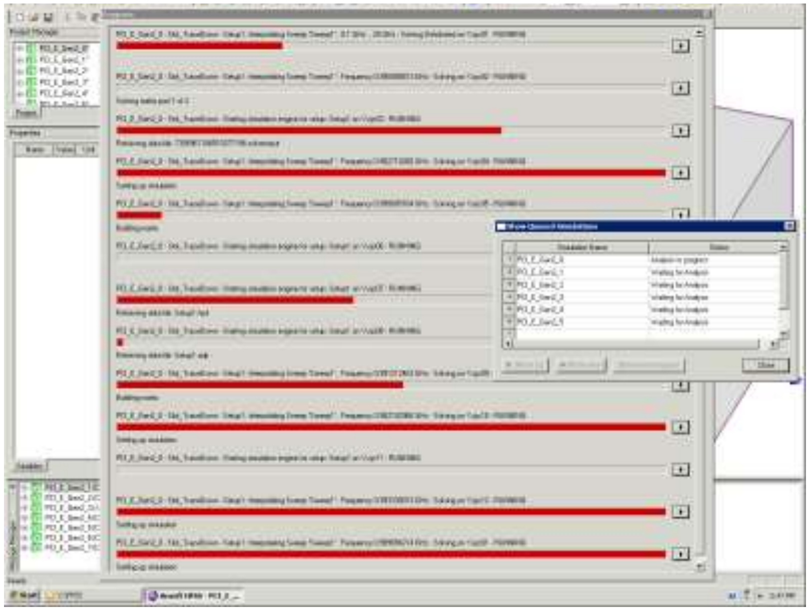
Parametric results

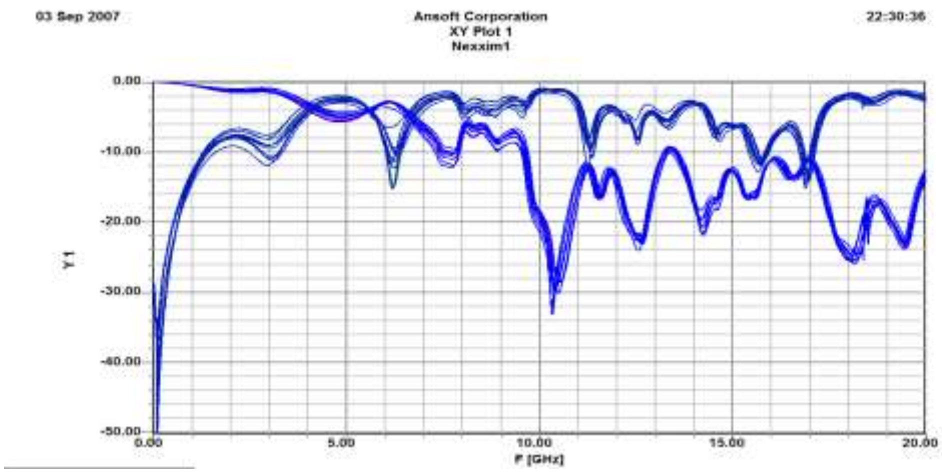






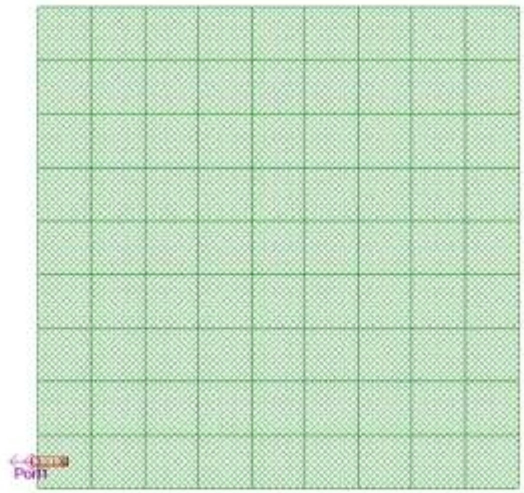
DSO runs multiple designs in parallel

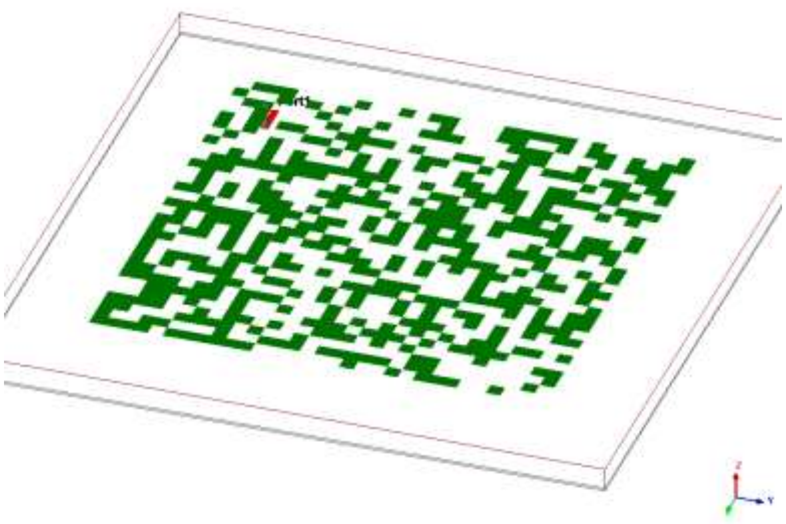




Minimization of the Resonance Frequency

- **Patch divided into "bits"**
- **Bits turned on and off**
  “1001010010101”





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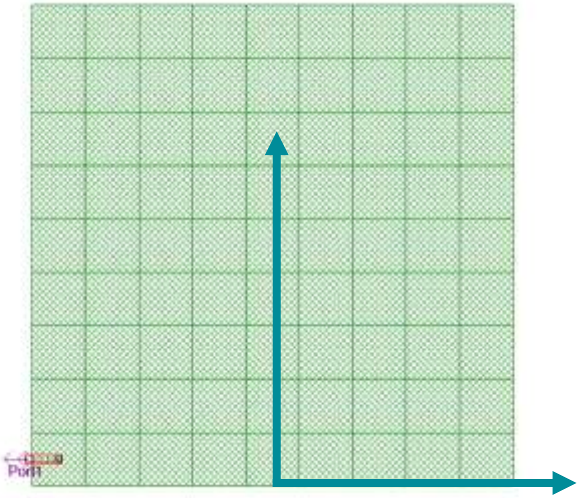
Minimization of the Resonance Frequency

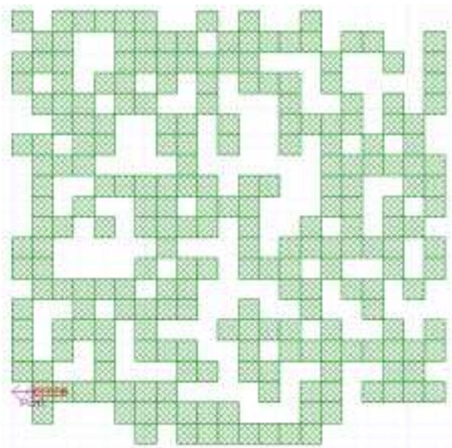
- **Resonance Definition: Peak of the Re[Z_{in}]**

- **Optimization *does not include* the location of the feed point**

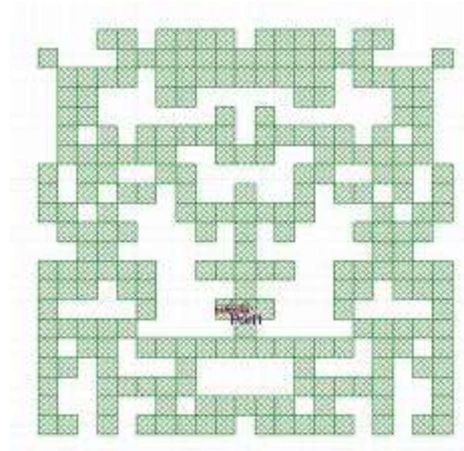


- **Cases investigated:**
  - **Symmetry NOT imposed**
  - **Symmetry imposed in the y-axis**
  - **Two different level of discretization:**
    - 21 by 21
    - 41 by 41

Symmetry



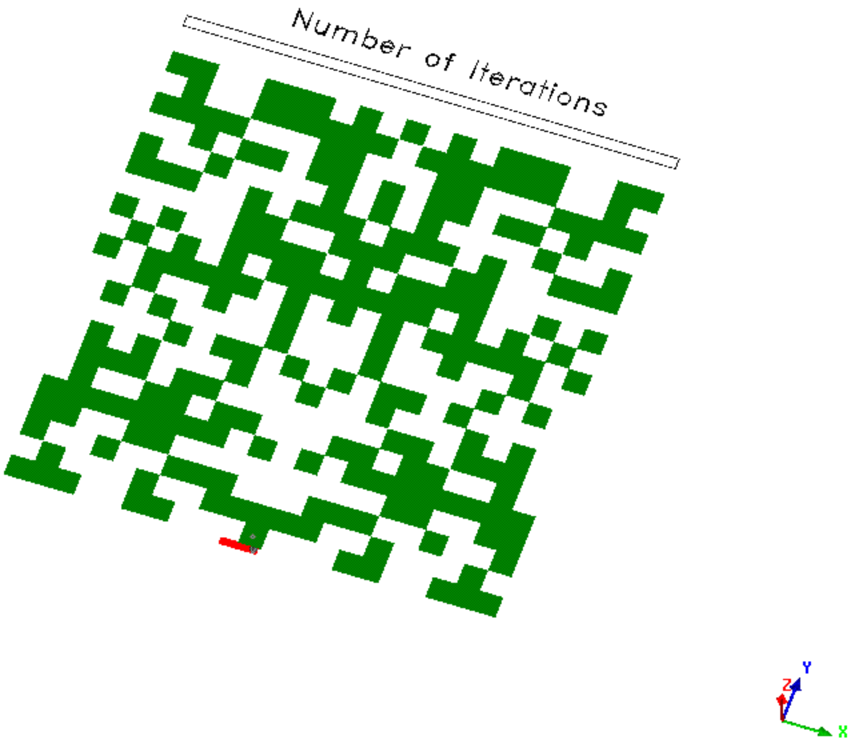
Asymmetric Patch



Symmetric Patch

Animation of Geometric Solution Convergence

- **21 X 21 Symmetric Patch**



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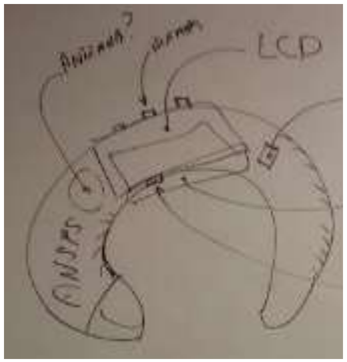
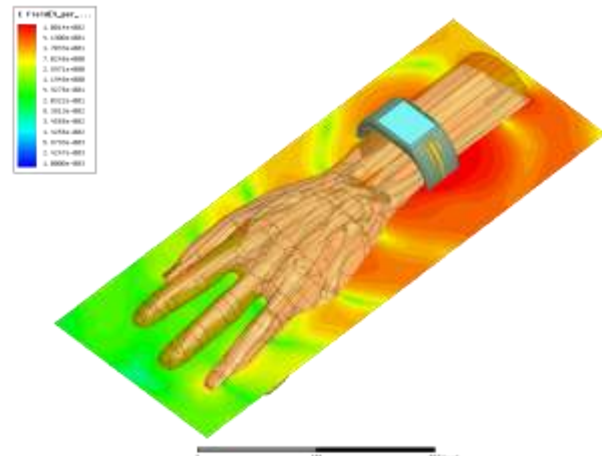
Successful Smart Watch Design Using ANSYS

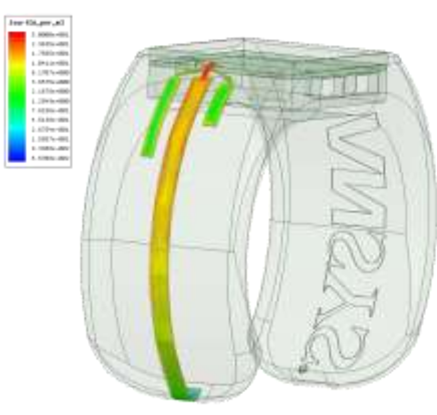


Watch Performance on Human Hand

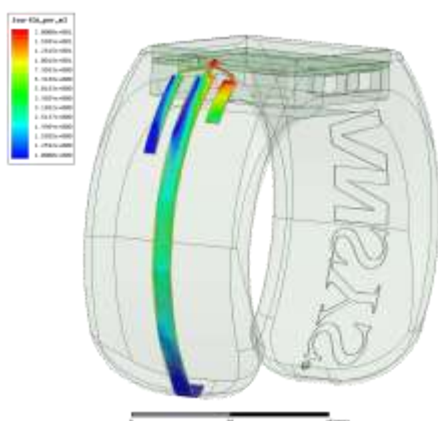


2400 MHz 1900 MHz 850 MHz

Current Distribution on Antenna Elements



.85 GHz



1.85 GHz

Courtesy Mike Schaaf, Synapse

