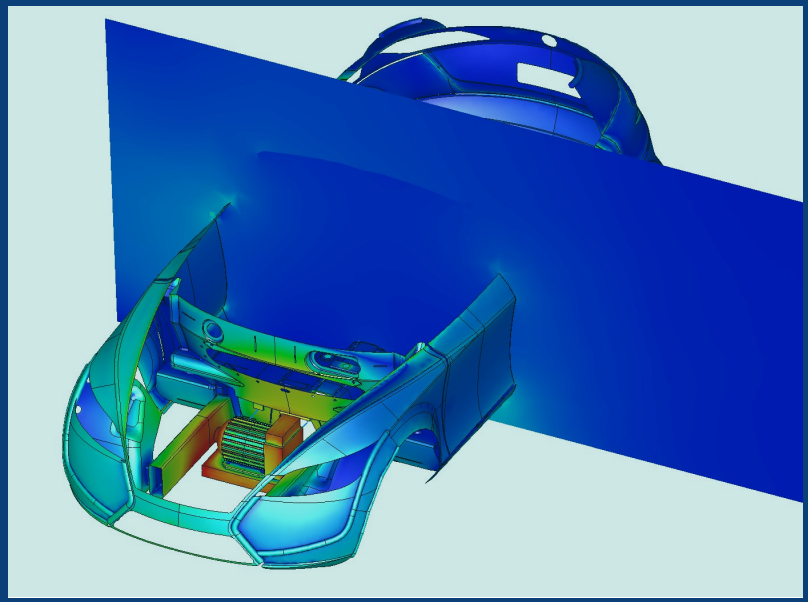
3D

V+R

3DEXPERIENCE®

电传动系统的电磁仿真



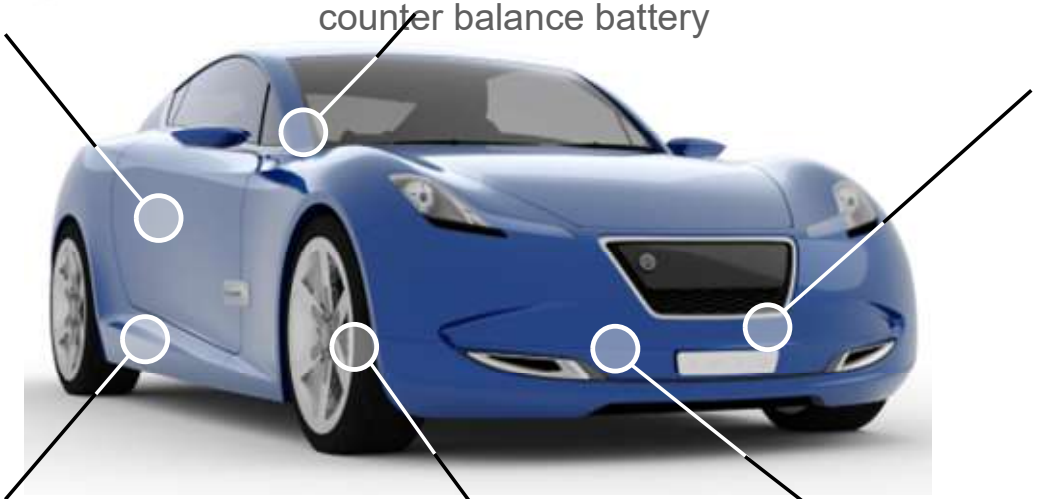
新一代汽车

车身

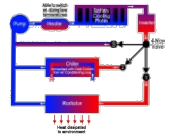
- High attention on weight management (light material) to counter balance battery

电气

- Dual tension cable technology in vehicle (high voltage & 12V)



HVAC



- Clean cooling (no contact with engine emission, oil, gas)
- No front grid required

电池

- 800 kg batteries = 92 kWh energy (vs 75 liters of gasoline= 750 kWh of energy)
- Filling time is several hours (vs 3 minutes for traditional tank)

底盘

- Simplified dynamics with very low center of gravity
- High modularization capabilities (packaging simplified)

电机

- 89 to 95% of efficiency (vs 25% for ICE)
- Immediate torque (no transmission required)

概述

电磁仿真

电机设计和优化

电传动系统中的传导发射

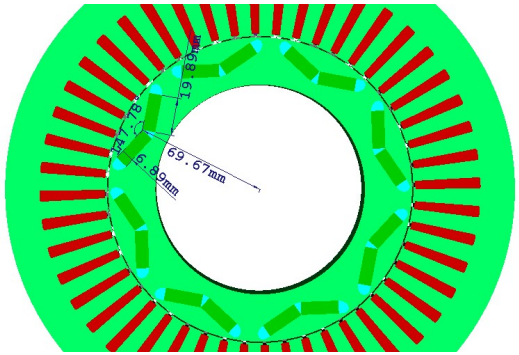
整车共模分析

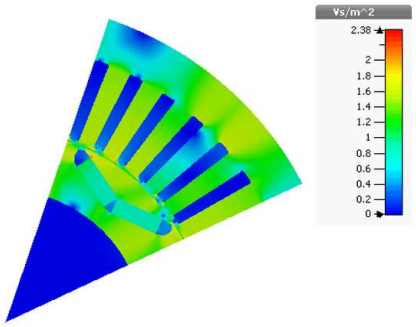
人体安全

总结

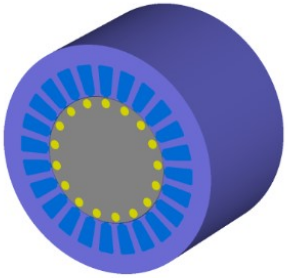
电机设计与优化

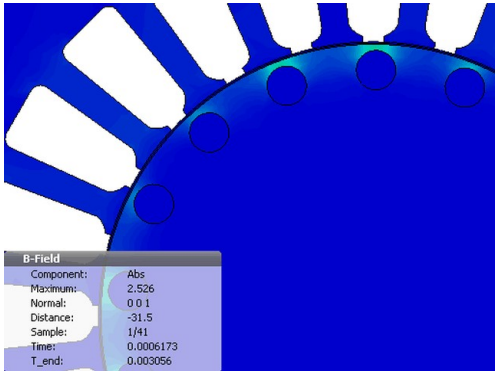
Permanent Magnet Synchronous Motor Optimization





4-Pole, 400Hz Induction Motor



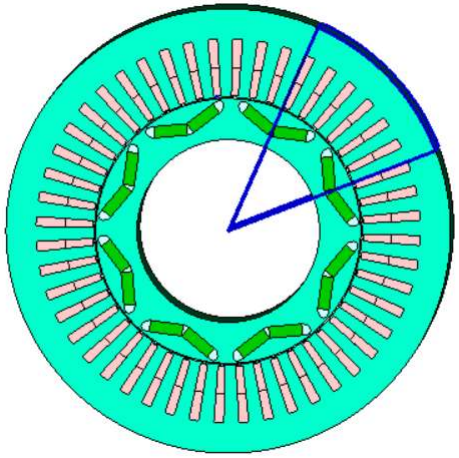


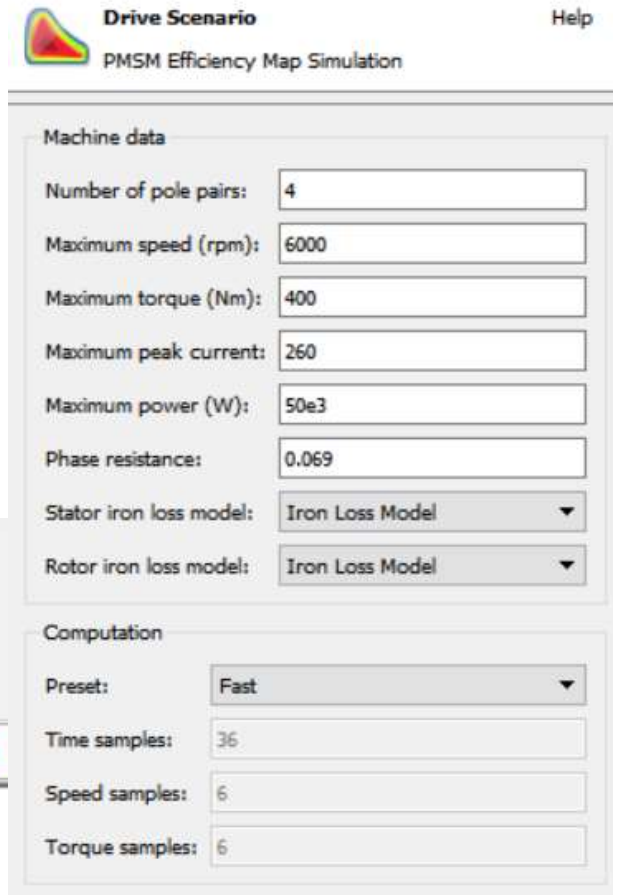
SIMULIA

DASSAULT SYSTEMES

电机

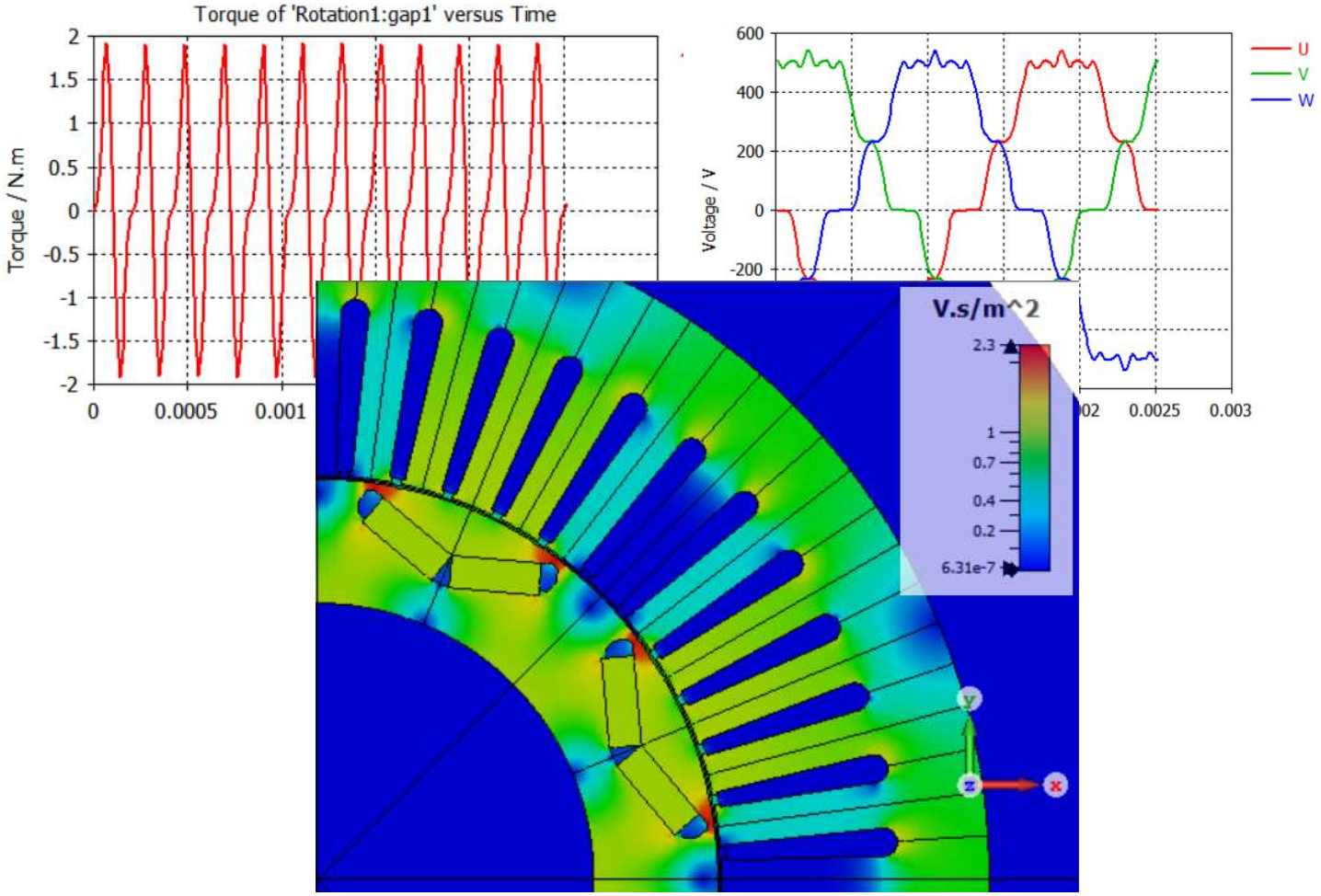
- 永磁同步电机的设计与优化





电机

- 空载/零电流
  - 齿槽转矩
  - 反电动势
  - 磁通量密度

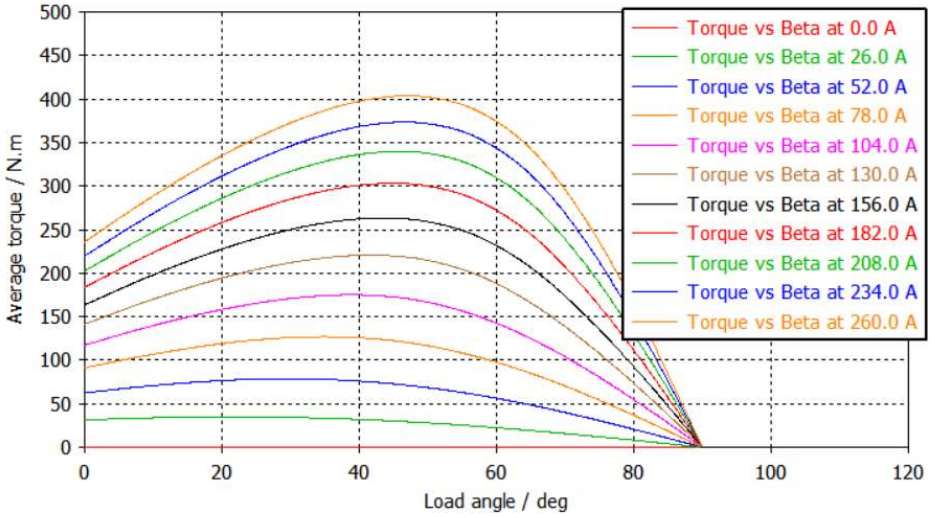


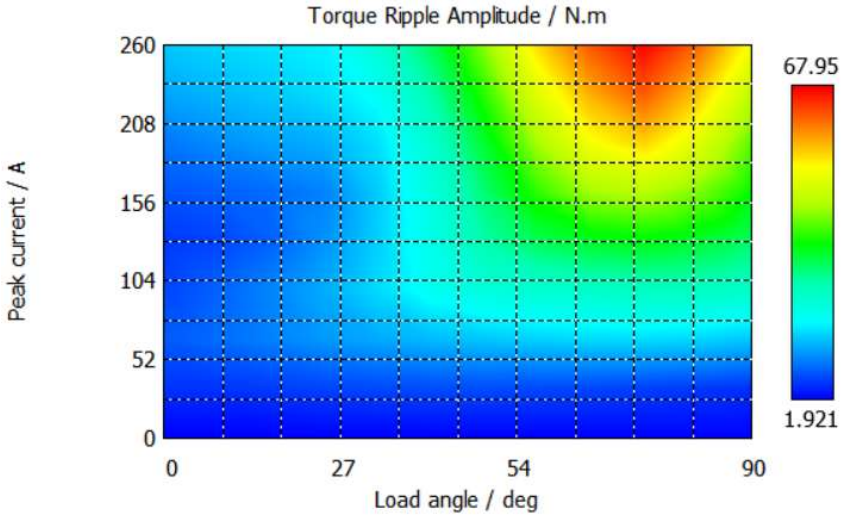
SIMULIA

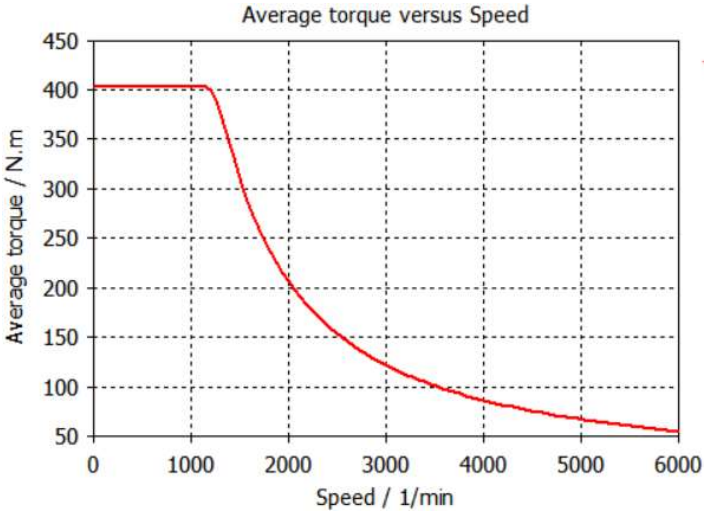
DASSAULT SYSTEMES

电机

- 负载操作
  - 扭矩与电流
  - 扭矩与速度曲线
  - 扭矩波动

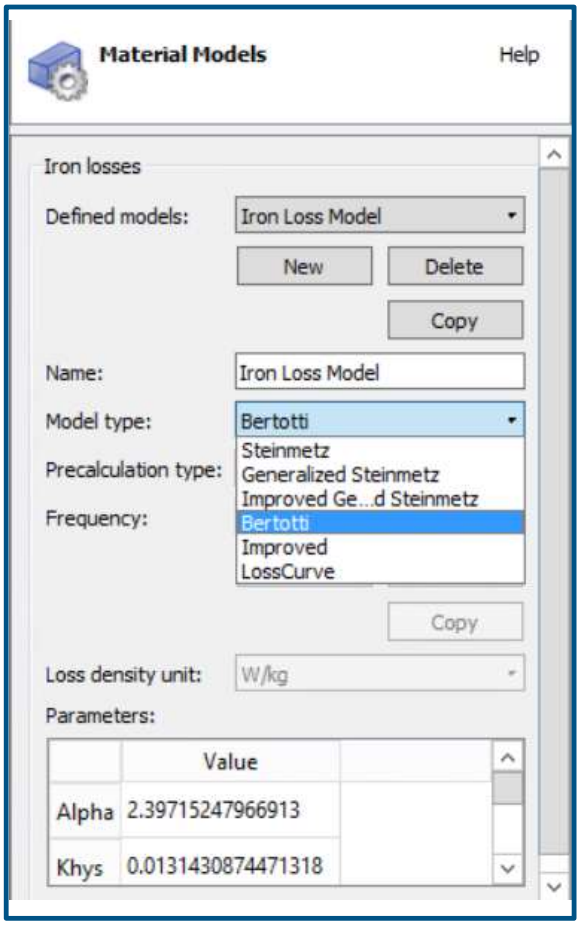


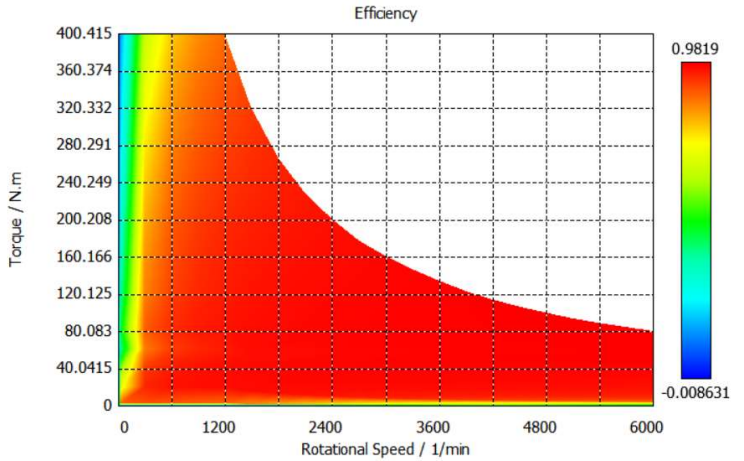


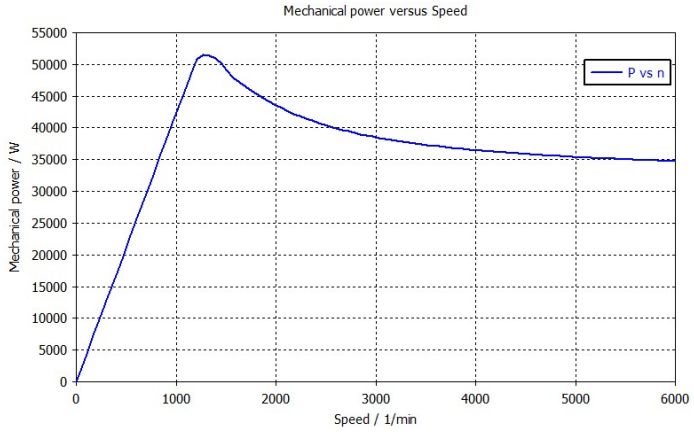


电机

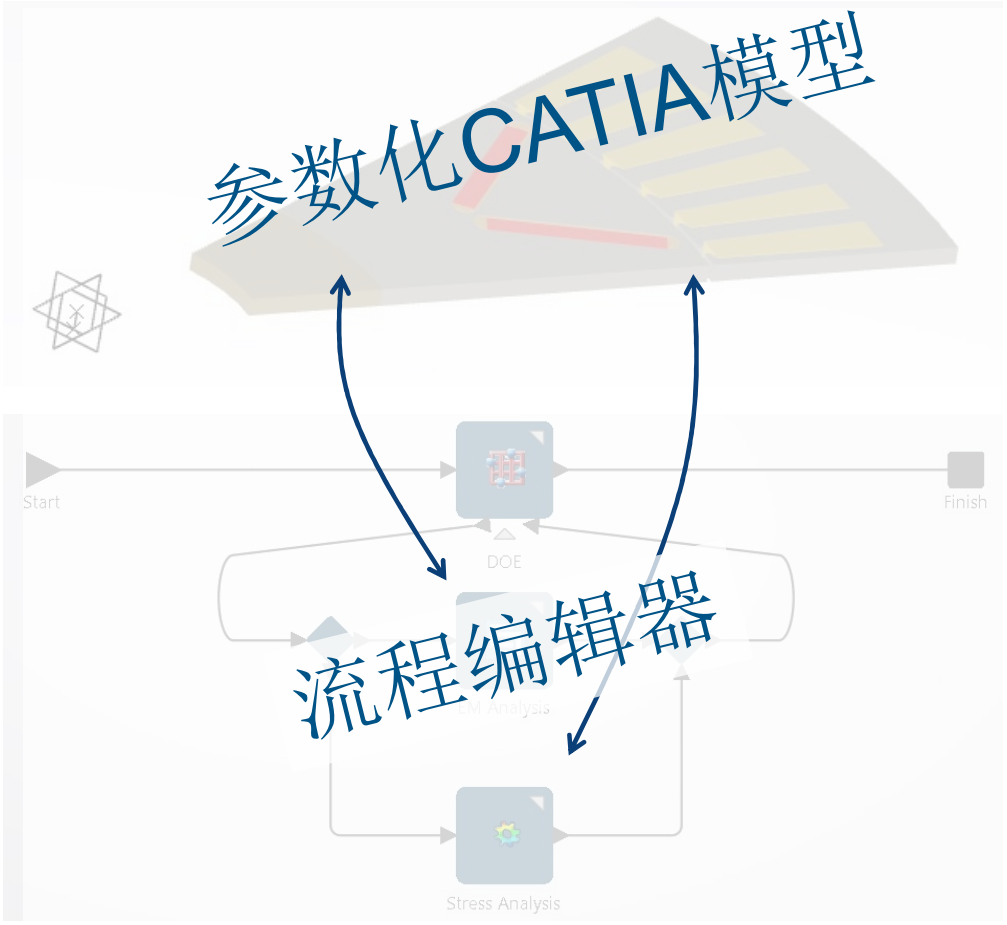
- υ 效率
  - ω 非线性材料
  - ω 铁损耗
  - ω 效率图





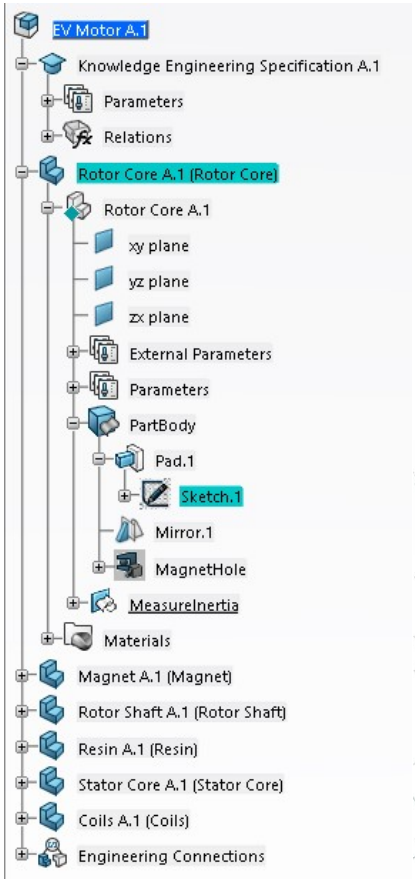


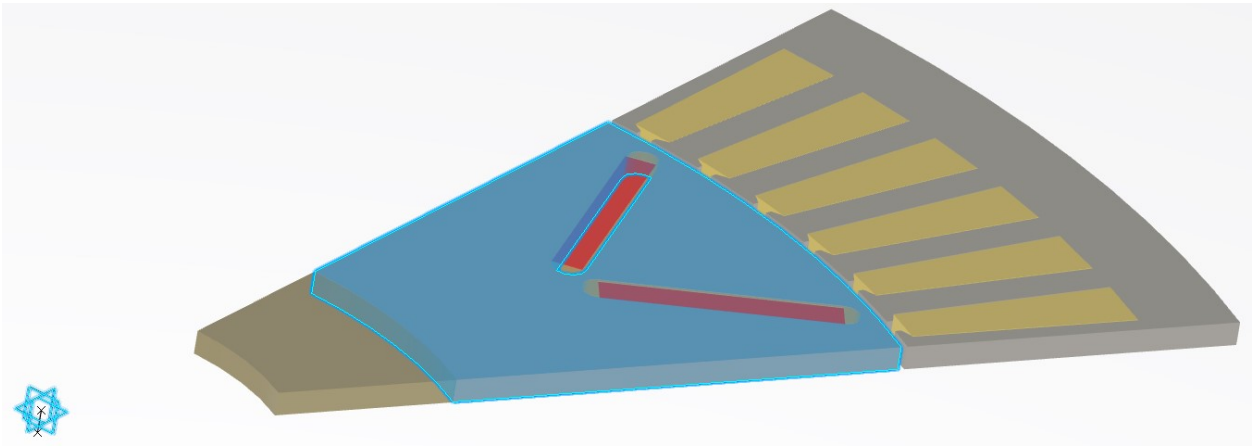
组合优化-多物理场

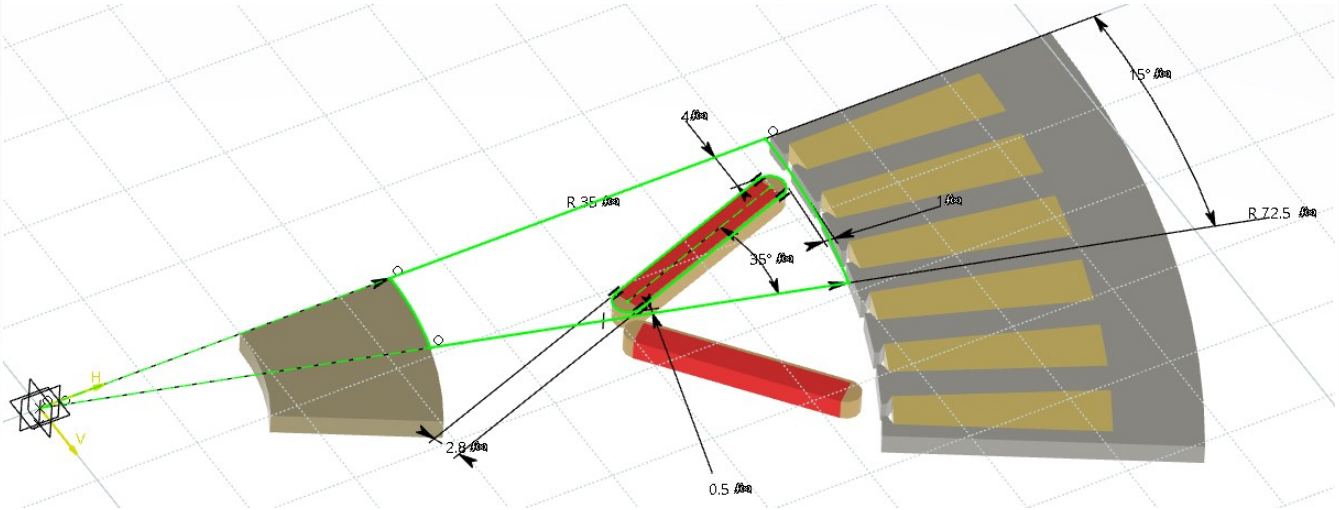


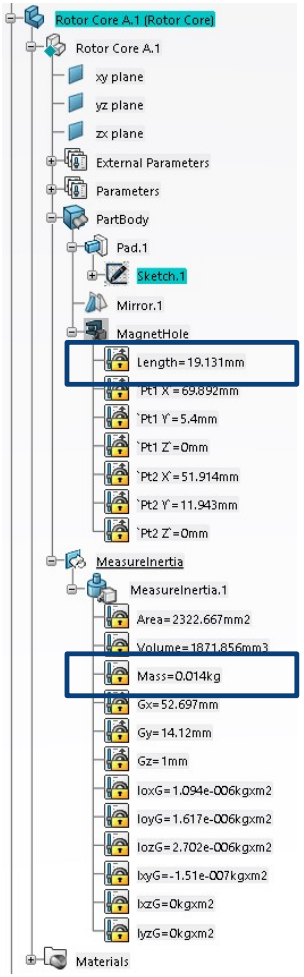
- 电磁KPI(CST Studio Suite Power ' by)
  - 最大扭矩
  - 最大化功率
  - 最小化扭矩波动
  - 尽量减少损失
  - 在故障条件下，尽量减少PM的退磁
- 应力KPI(3DX/Abaqus上的Physics Simulation应用程序)
  - 给定阈值下的离心载荷(20000 rpm)和/或热载荷的 Von mises 应力值

创建结构→ 参数化

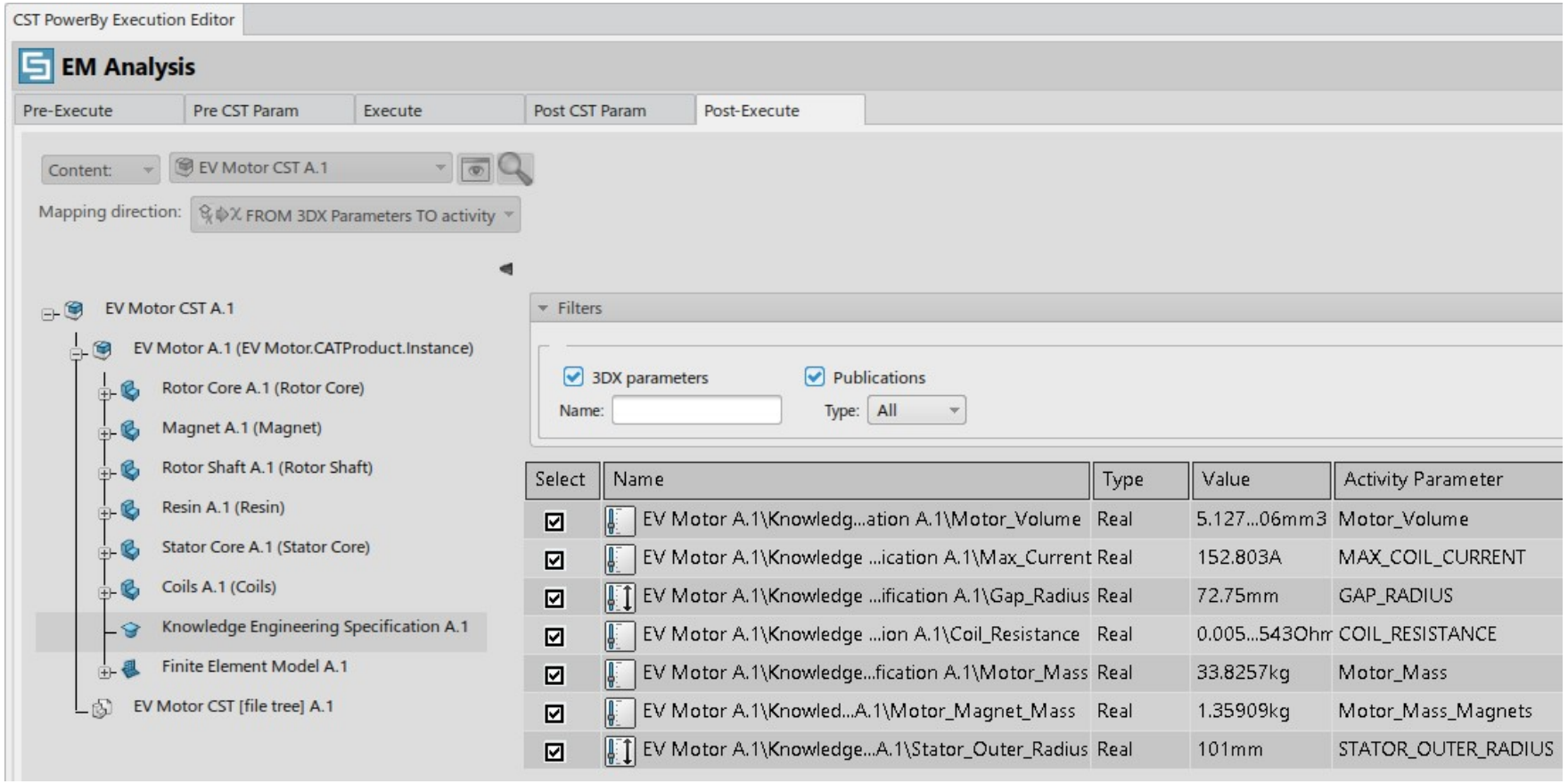




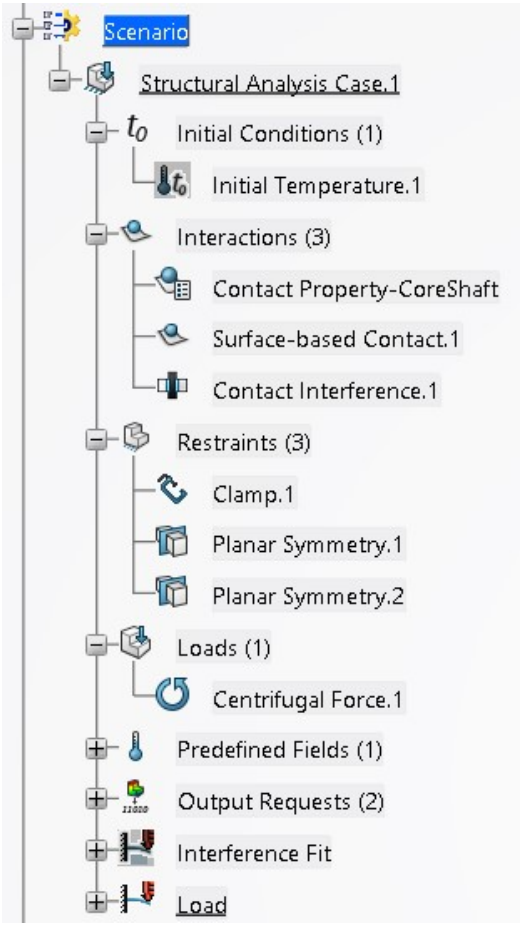




EM Analysis：电磁场景

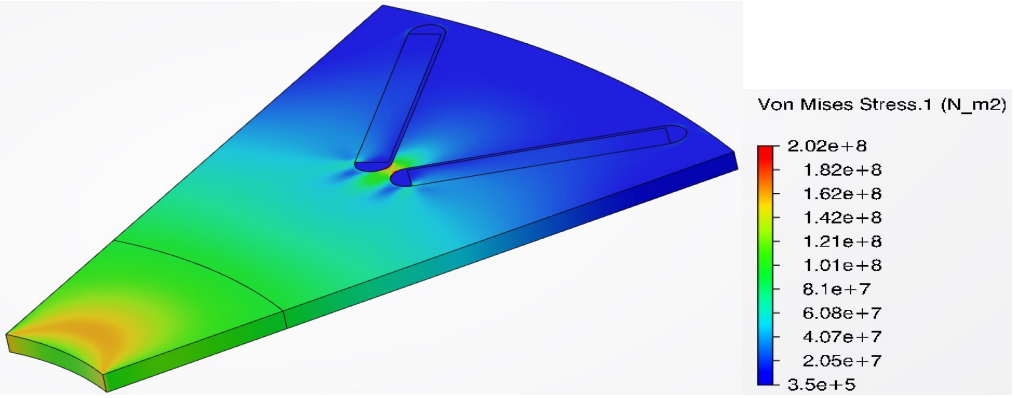


Stress Analysis： 力学场景



Feature Manager

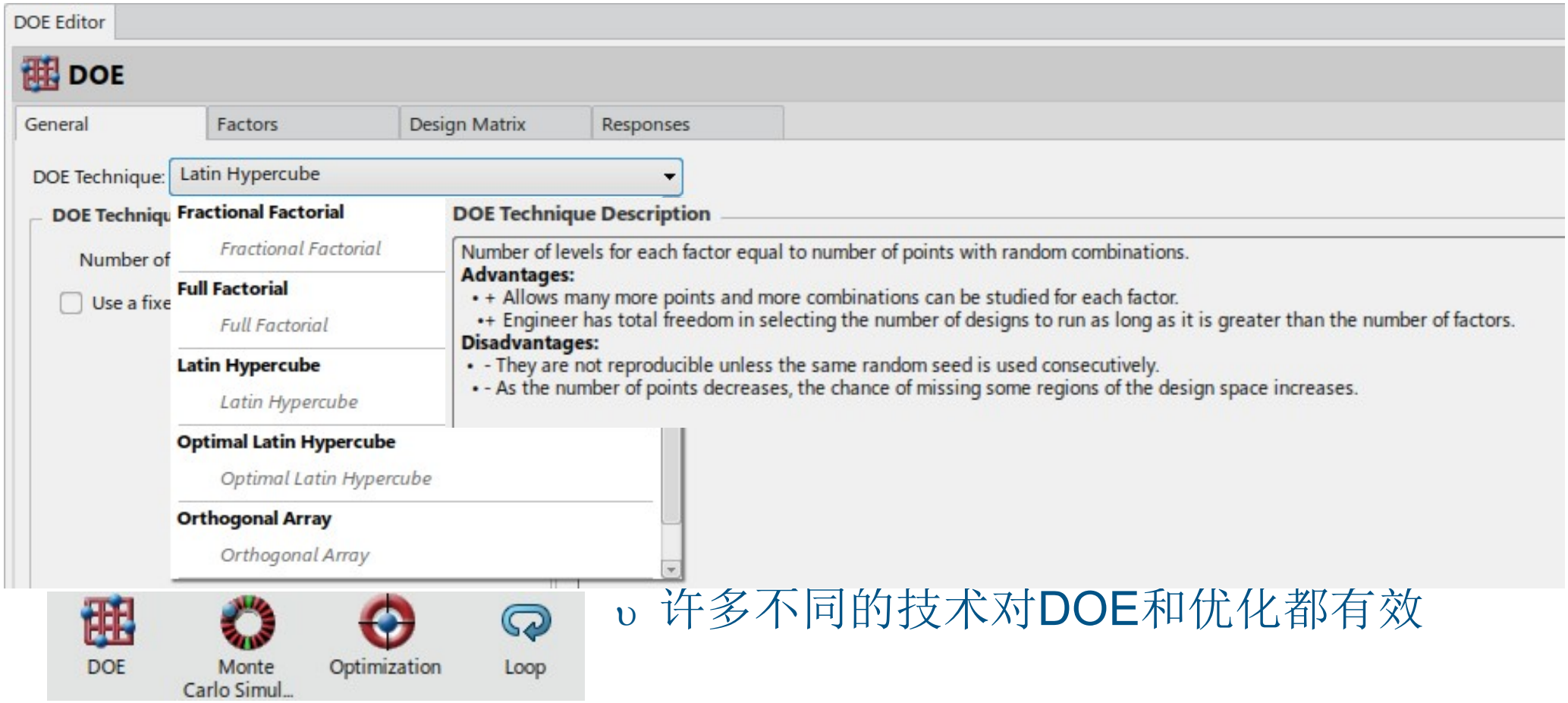
	..	Name	Type	Category	Definition	Interference Fit	Load
☑		Clamp.1	Clamp	Restraints			
☑		Contact Interference.1	Contact Interference	Interactions	-0.03 mm		
☑		Output.1	Field	Output Requests	Field		
☑		Output.2	History	Output Requests	History		
☑		Planar Symmetry.1	Planar Symmetry	Restraints			
☑		Planar Symmetry.2	Planar Symmetry	Restraints			
☑		Surface-based Contact.1	Surface-based Contact	Interactions	COF=0		
☑		Centrifugal Force.1	Centrifugal Force	Loads	20000 turn_mn		
☐		*Prescribed Temperature.1*	*Prescribed Temperature*	*Predefined Fields*	*193 Kdeg*		
		Contact Property-CoreShaft	Contact Property	Interactions			
		Global Element Types	Global Element Map	Element Type Assignments			
☑		Initial Temperature.1	Initial Temperature	Initial Conditions	293 Kdeg		



SIMULIA

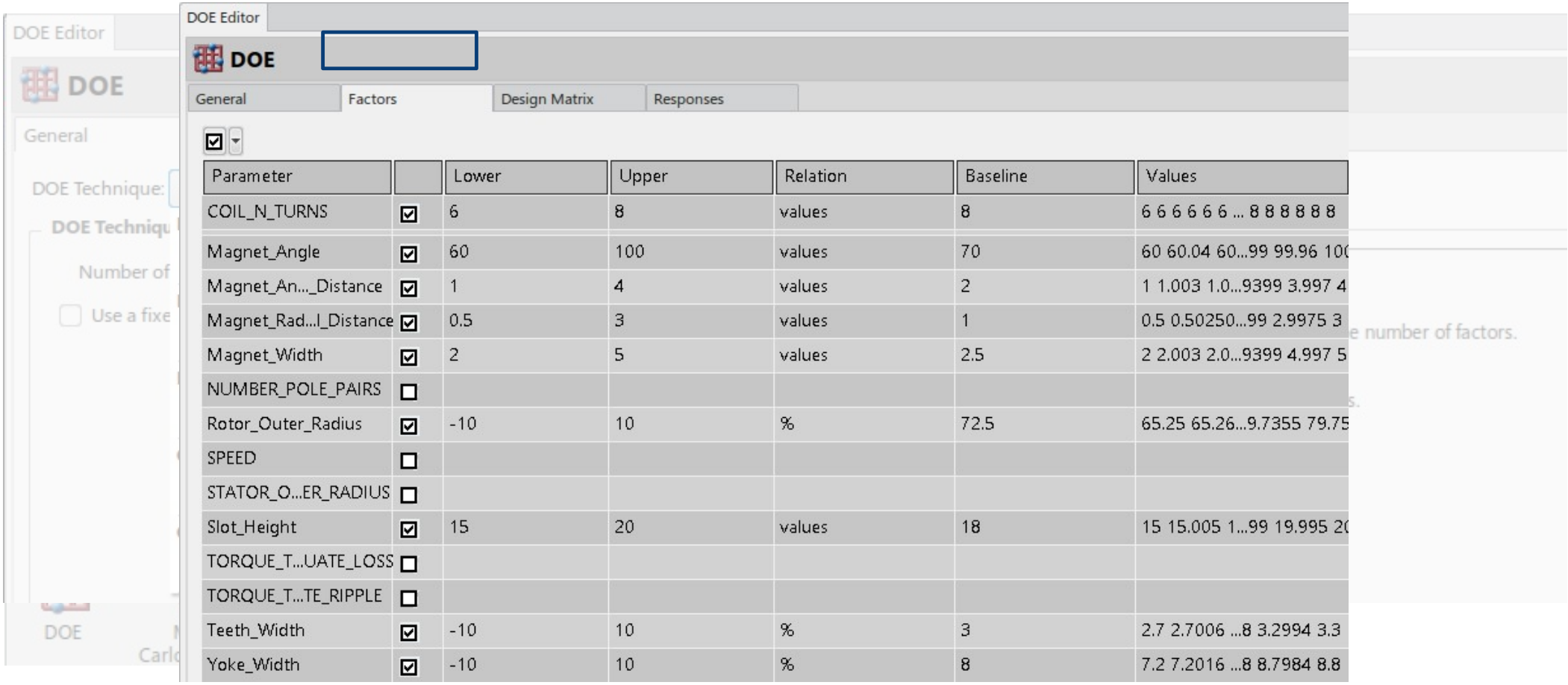
DASSAULT SYSTEMES

Process Composer : DOE / 优化



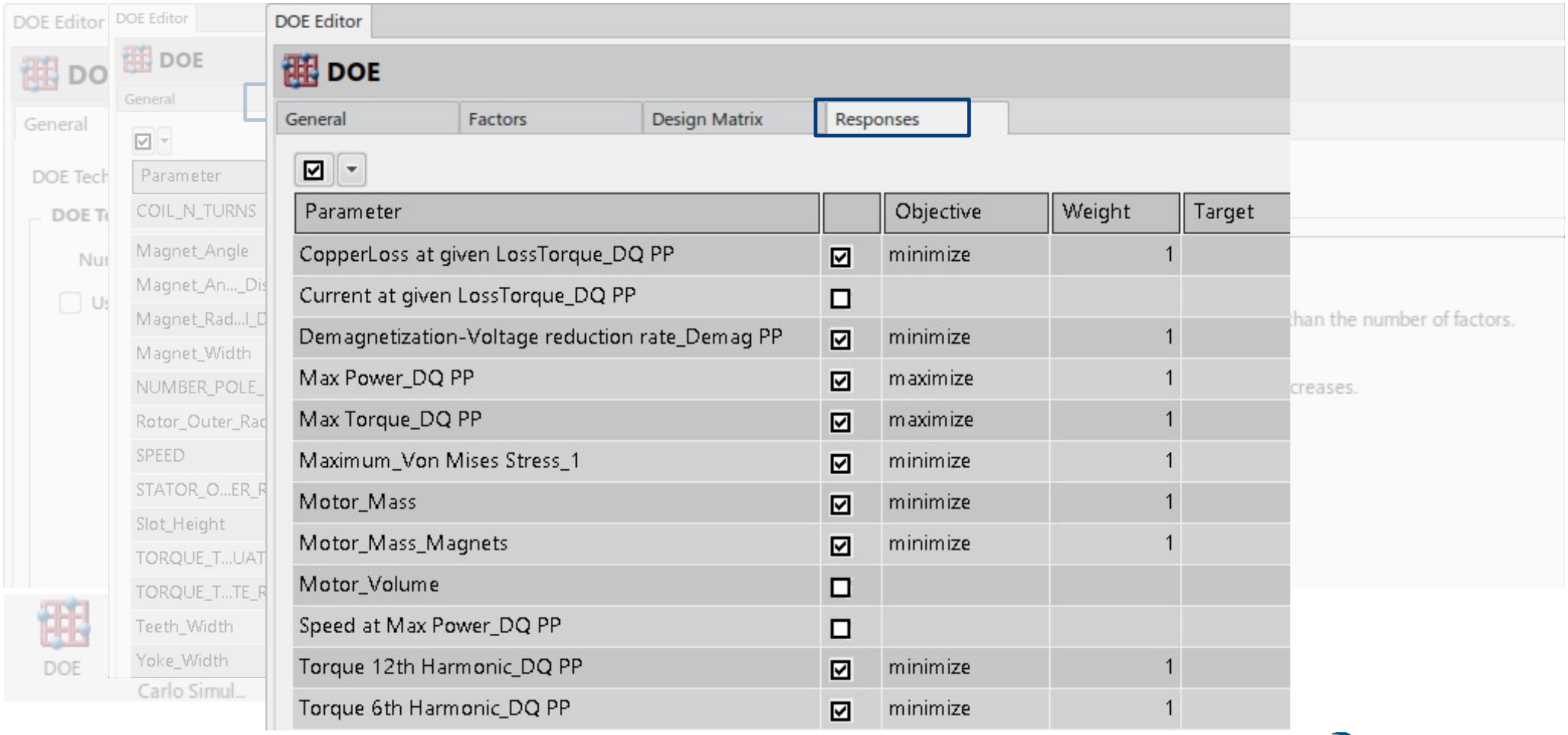
- 许多不同的技术对DOE和优化都有效

Process Composer : DOE / 优化

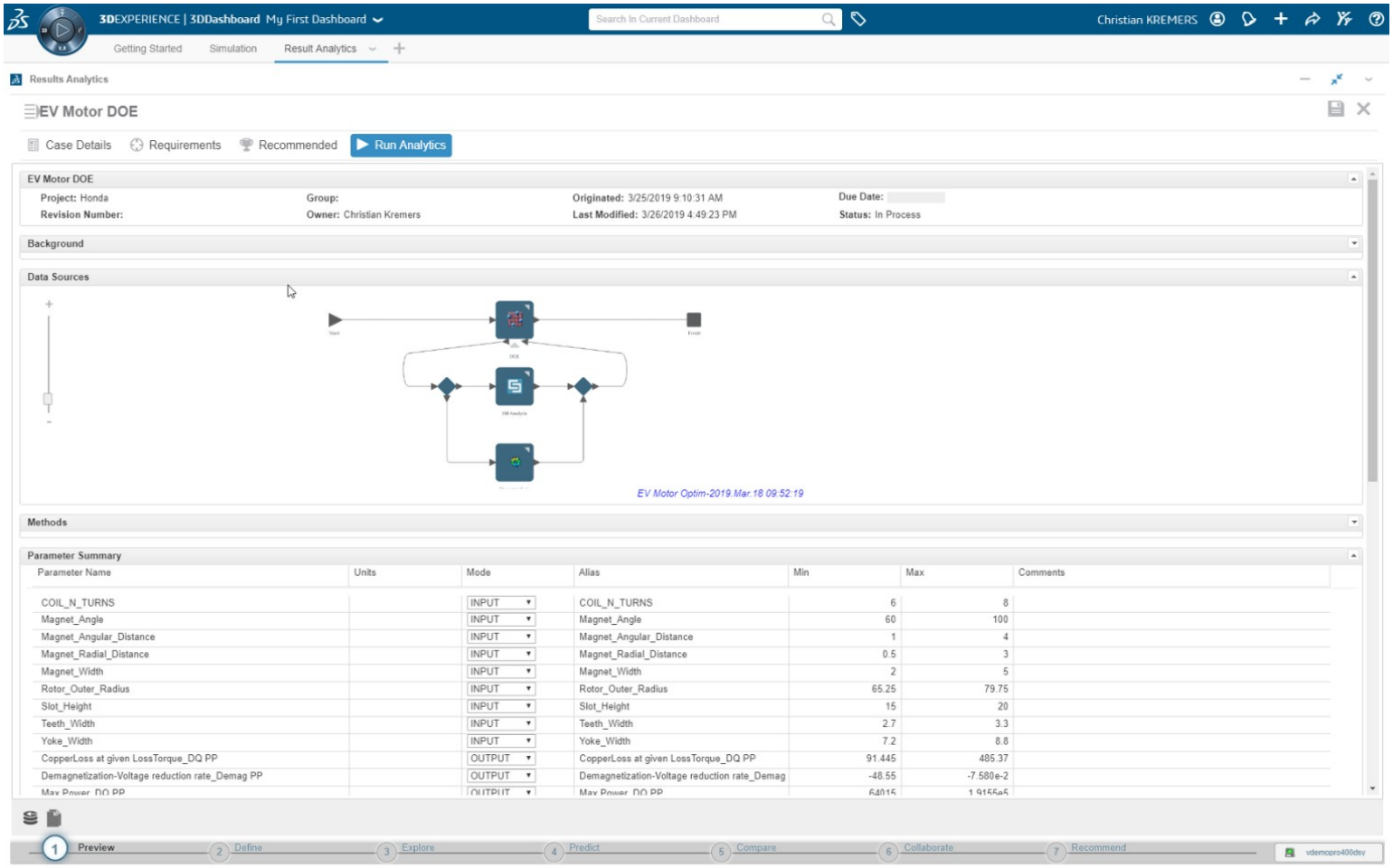


Parameter		Lower	Upper	Relation	Baseline	Values
COIL_N_TURNS	☑	6	8	values	8	6 6 6 6 6 6 ... 8 8 8 8 8 8
Magnet_Angle	☑	60	100	values	70	60 60.04 60...99 99.96 10
Magnet_An..._Distance	☑	1	4	values	2	1 1.003 1.0...9399 3.997 4
Magnet_Rad...l_Distance	☑	0.5	3	values	1	0.5 0.50250...99 2.9975 3
Magnet_Width	☑	2	5	values	2.5	2 2.003 2.0...9399 4.997 5
NUMBER_POLE_PAIRS	☐					
Rotor_Outer_Radius	☑	-10	10	%	72.5	65.25 65.26...9.7355 79.75
SPEED	☐					
STATOR_O...ER_RADIUS	☐					
Slot_Height	☑	15	20	values	18	15 15.005 1...99 19.995 2
TORQUE_T...UATE_LOSS	☐					
TORQUE_T...TE_RIPPLE	☐					
Teeth_Width	☑	-10	10	%	3	2.7 2.7006 ...8 3.2994 3.3
Yoke_Width	☑	-10	10	%	8	7.2 7.2016 ...8 8.7984 8.8

Process Composer : DOE / 优化



使用Result Analytics进行数据研究



SIMULIA

DASSAULT SYSTEMES

EMC/EMI

SIMULIA

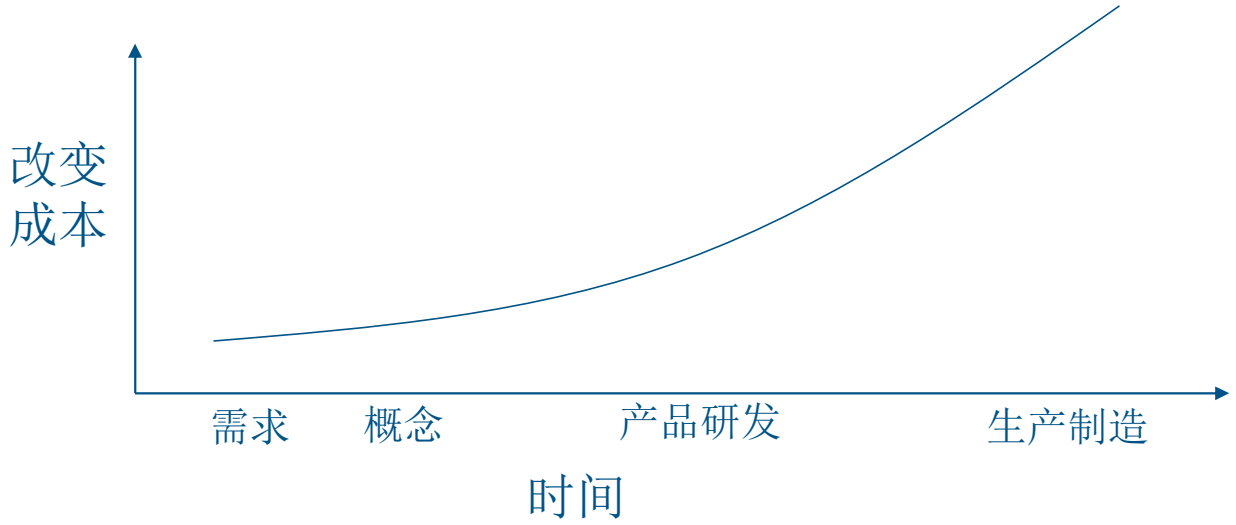
DASSAULT SYSTEMES

EMC/EMI范围

- 电气系统工作的能力
  - 在电磁环境中
  - 不影响周围设备(发射)
  - 或不受到周围设备的影响(敏感度)
- 对所有产品EMC合规都至关重要！
  - 发射和抗扰度是一个监管良好的领域
  - 汽车OEM对零部件实施严格的标准

仿真的动机

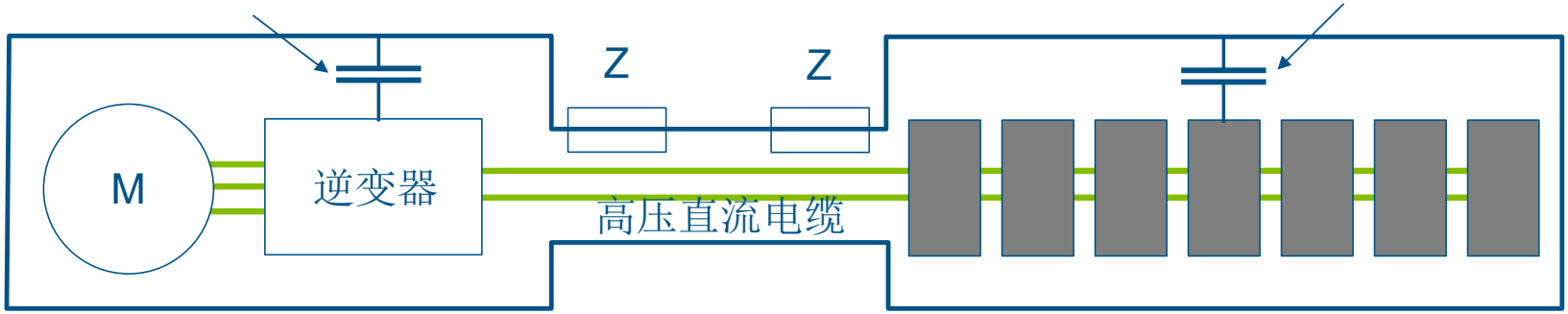
- EMC作为设计流程的一部分，有助于避免:
  - 多次troubleshooting迭代
  - 更正的高工作量和成本
  - 上市时间延迟



传动系统传导发射

IGBTs的容性输出耦合

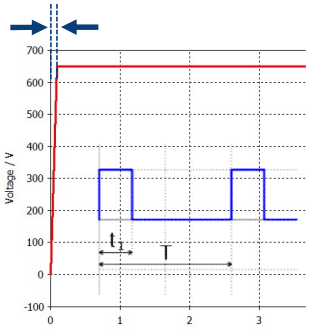
模块的容性输出耦合



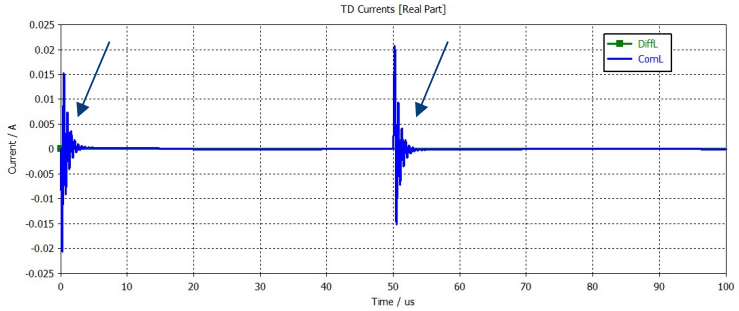
集成电机

高压电池系统

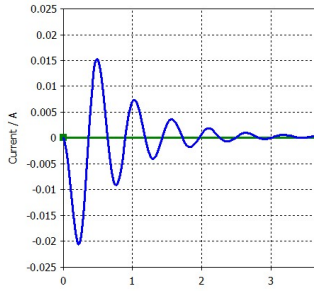
陡峭的上升和下降沿



双绞线对的串扰影响



反射导致的振铃



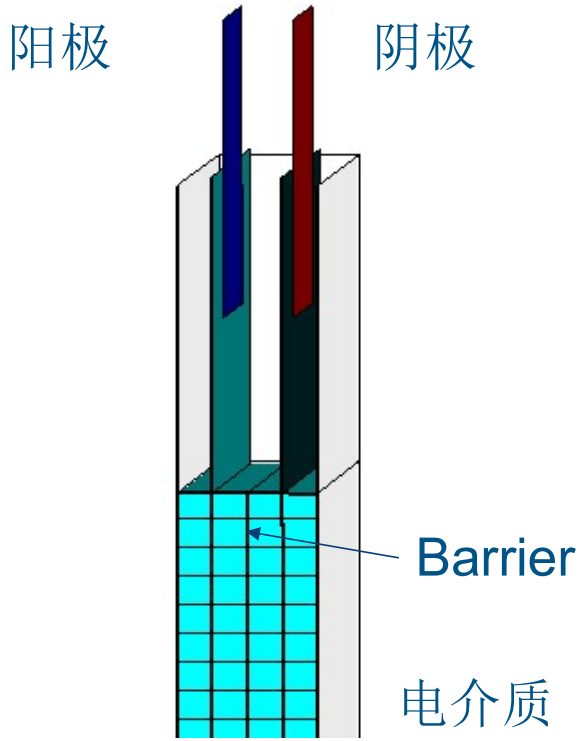
器件仿真

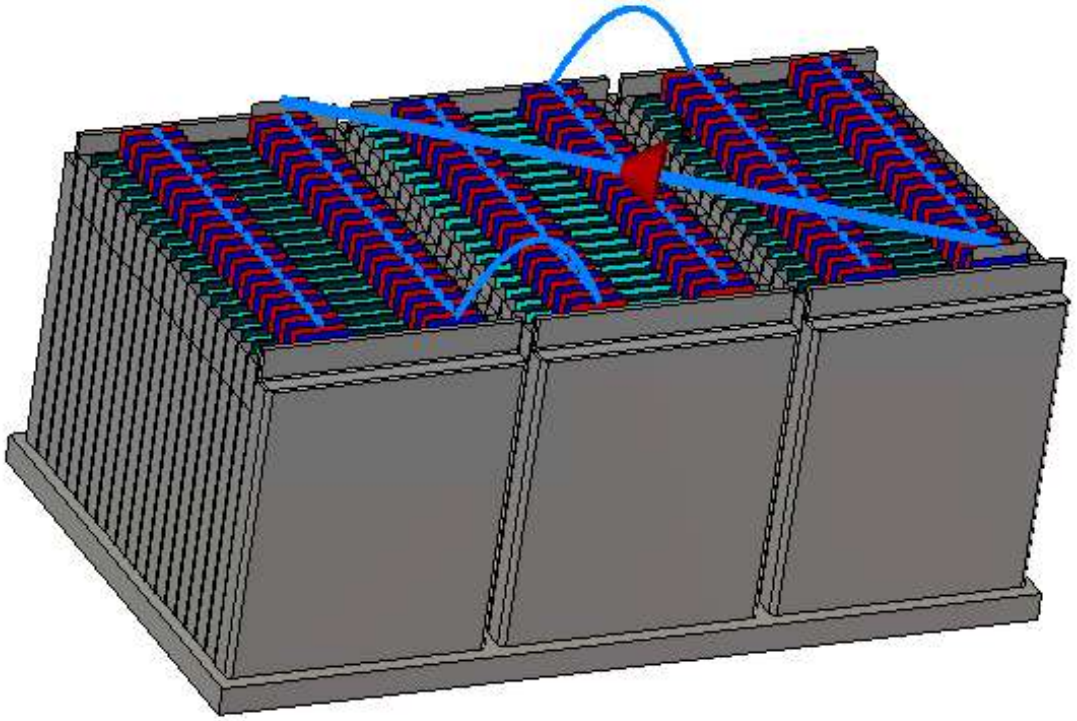
特征阻抗提取

SIMULIA

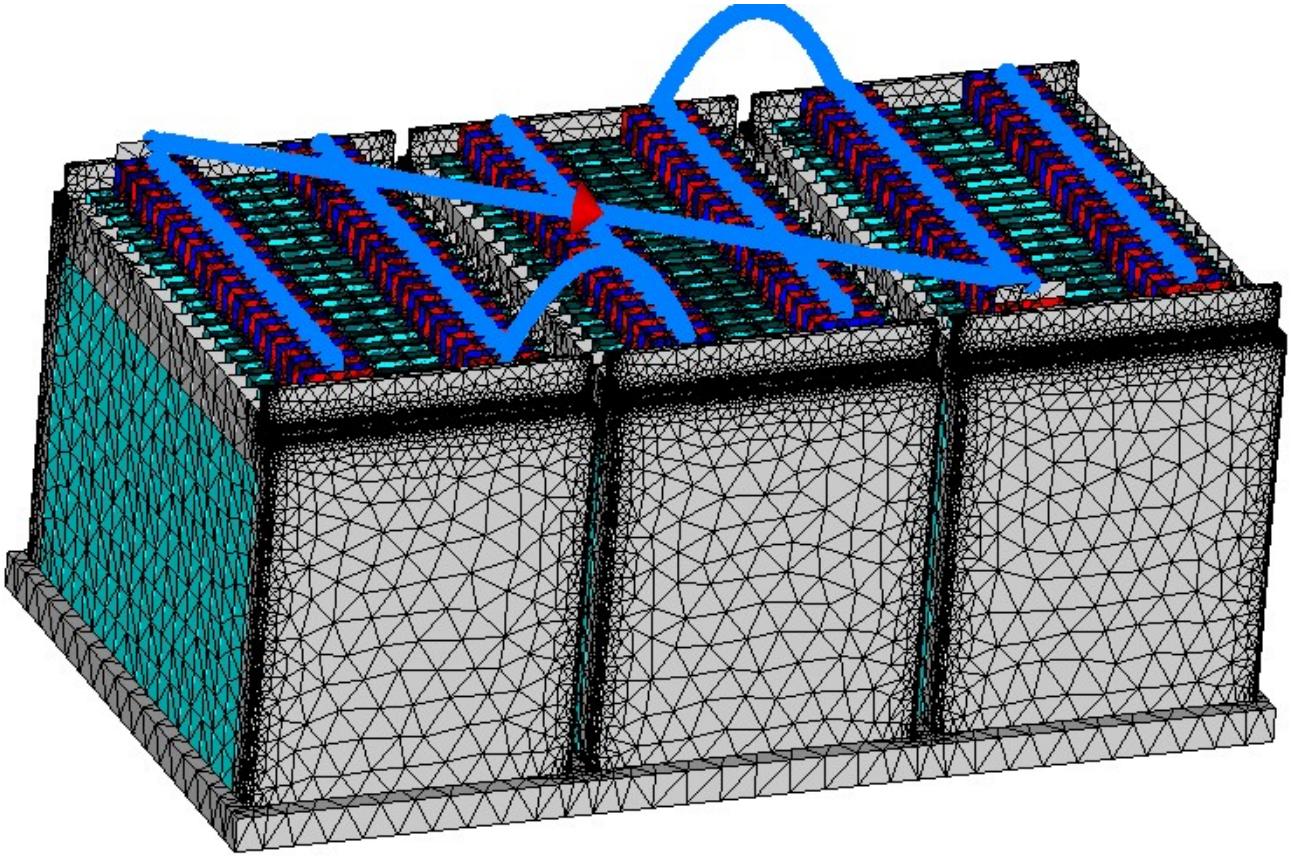
DASSAULT SYSTEMES

电池建模

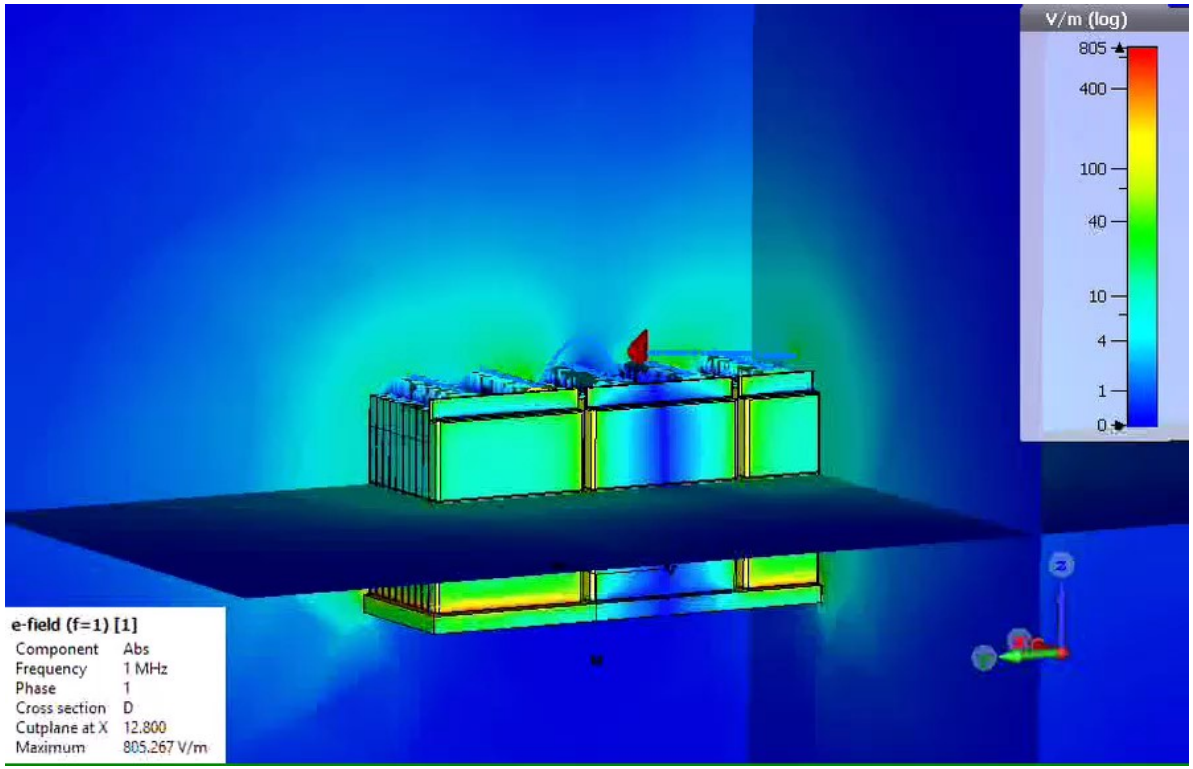


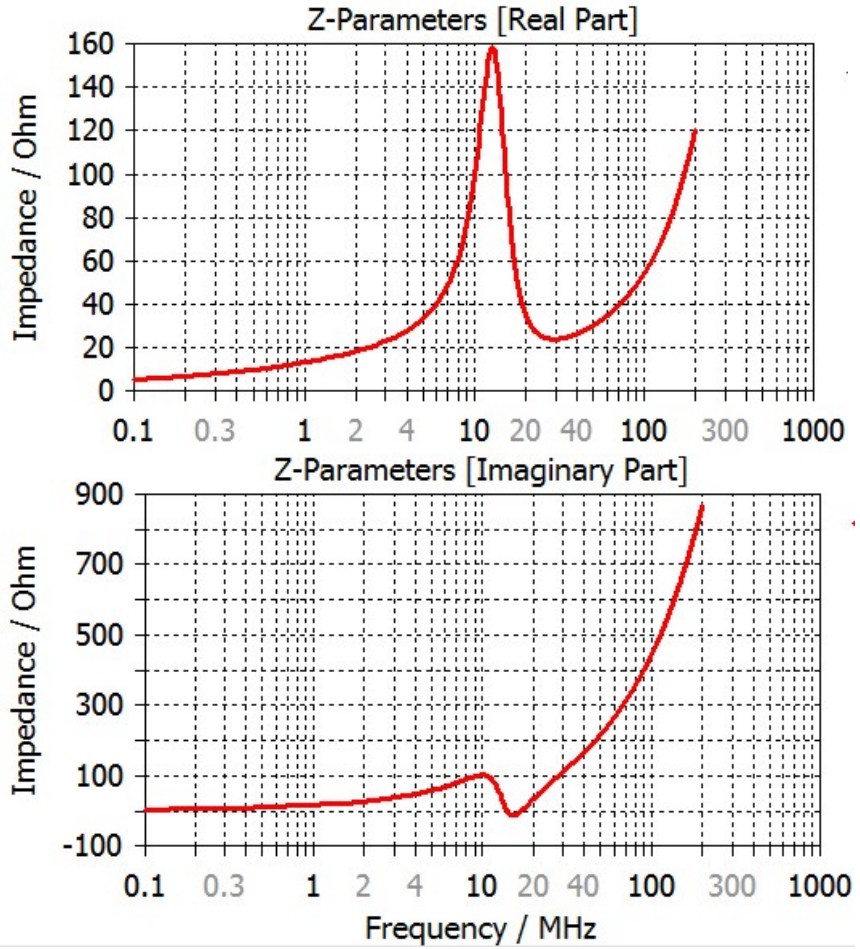


电池建模-网格



电池阻抗提取

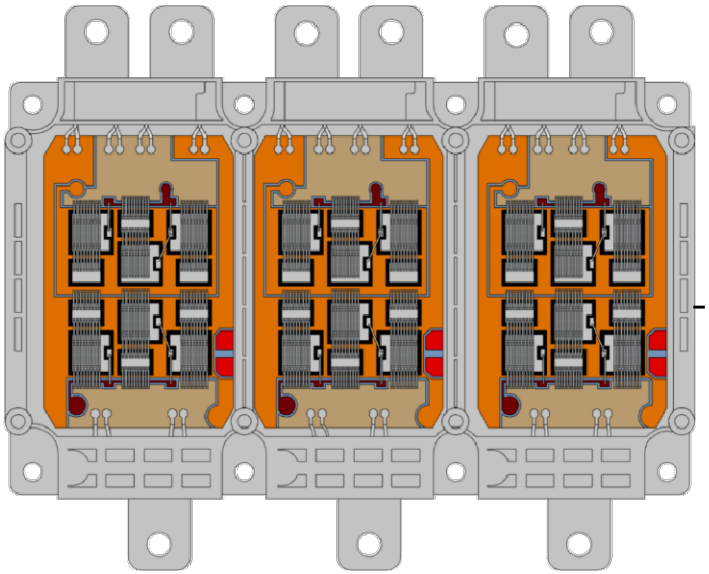


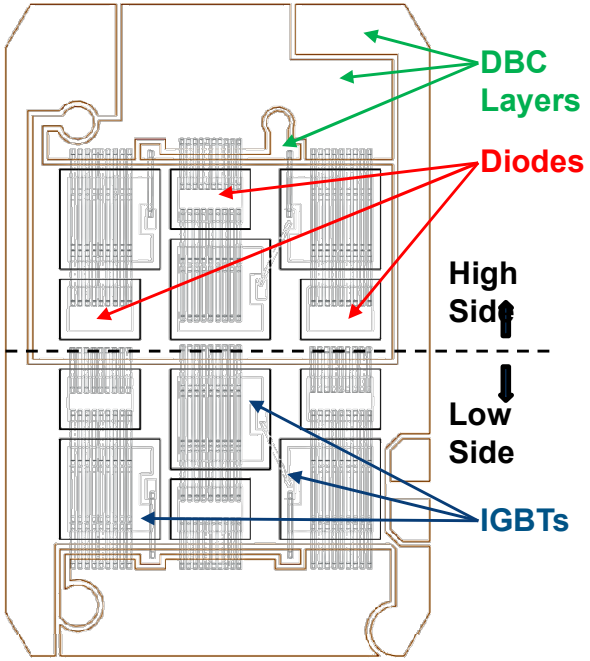


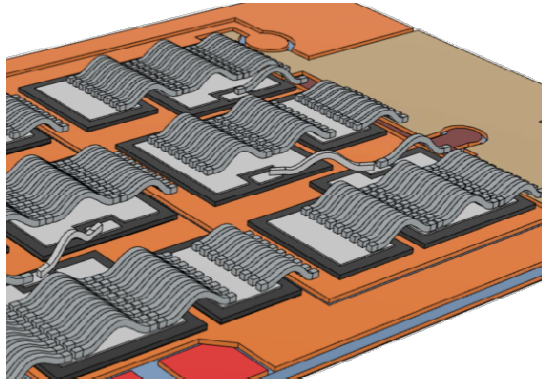
SIMULIA

DASSAULT SYSTEMES

逆变器



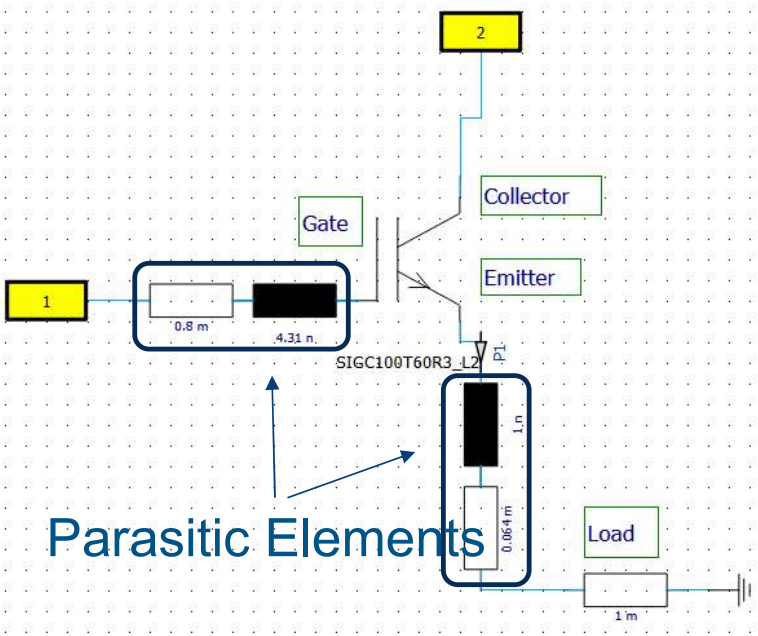


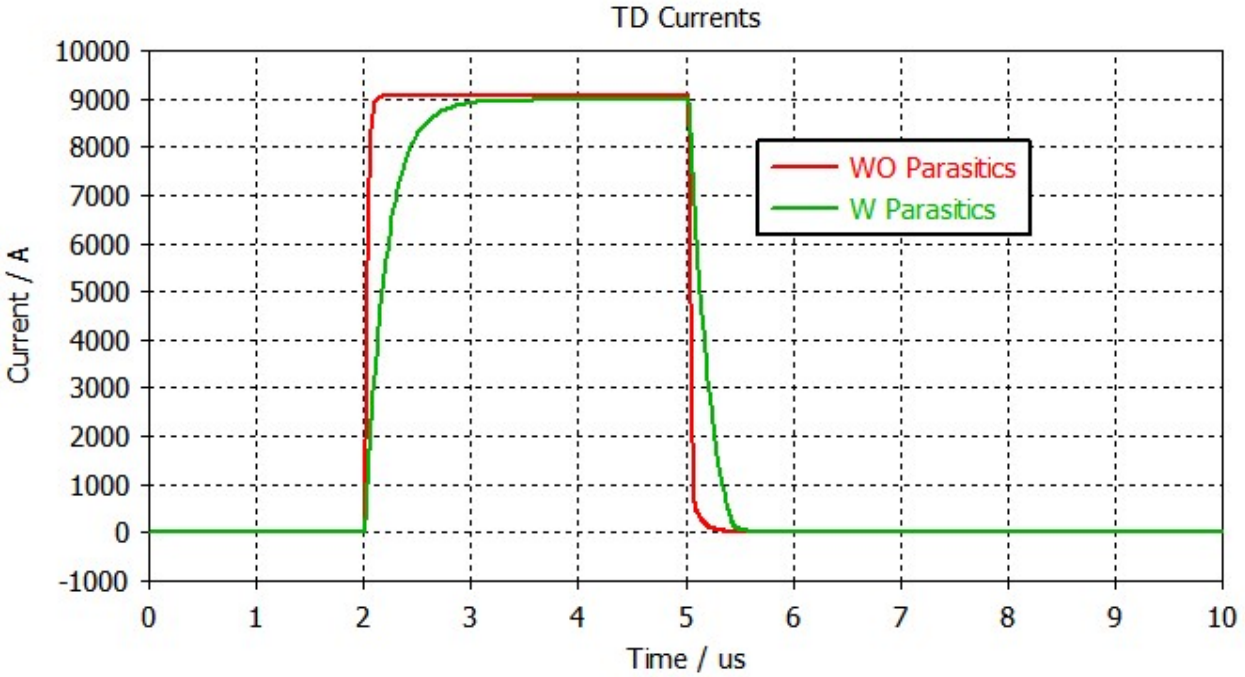


Wirebonds connecting IGBTs, Diodes and DBC Layers

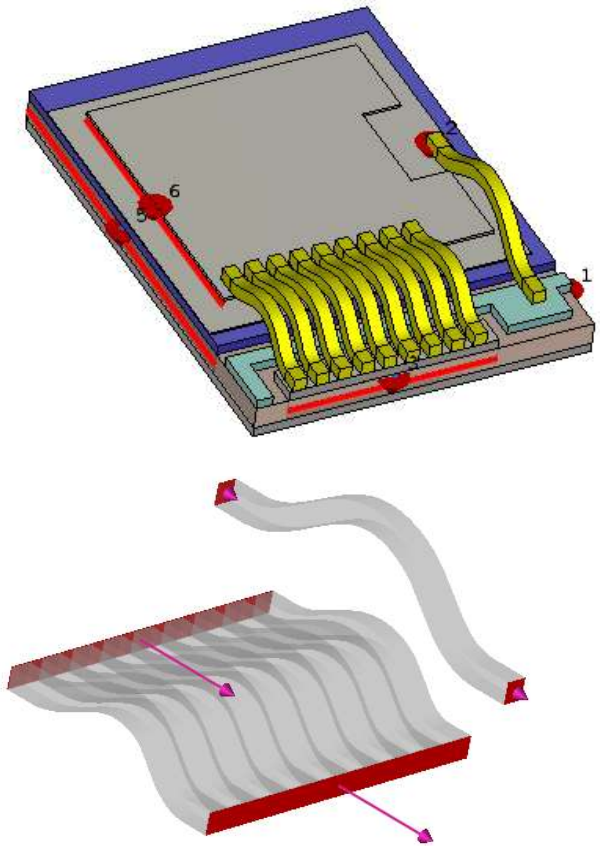
Wirebonds connecting IGBTs, Diodes and DBC Layers

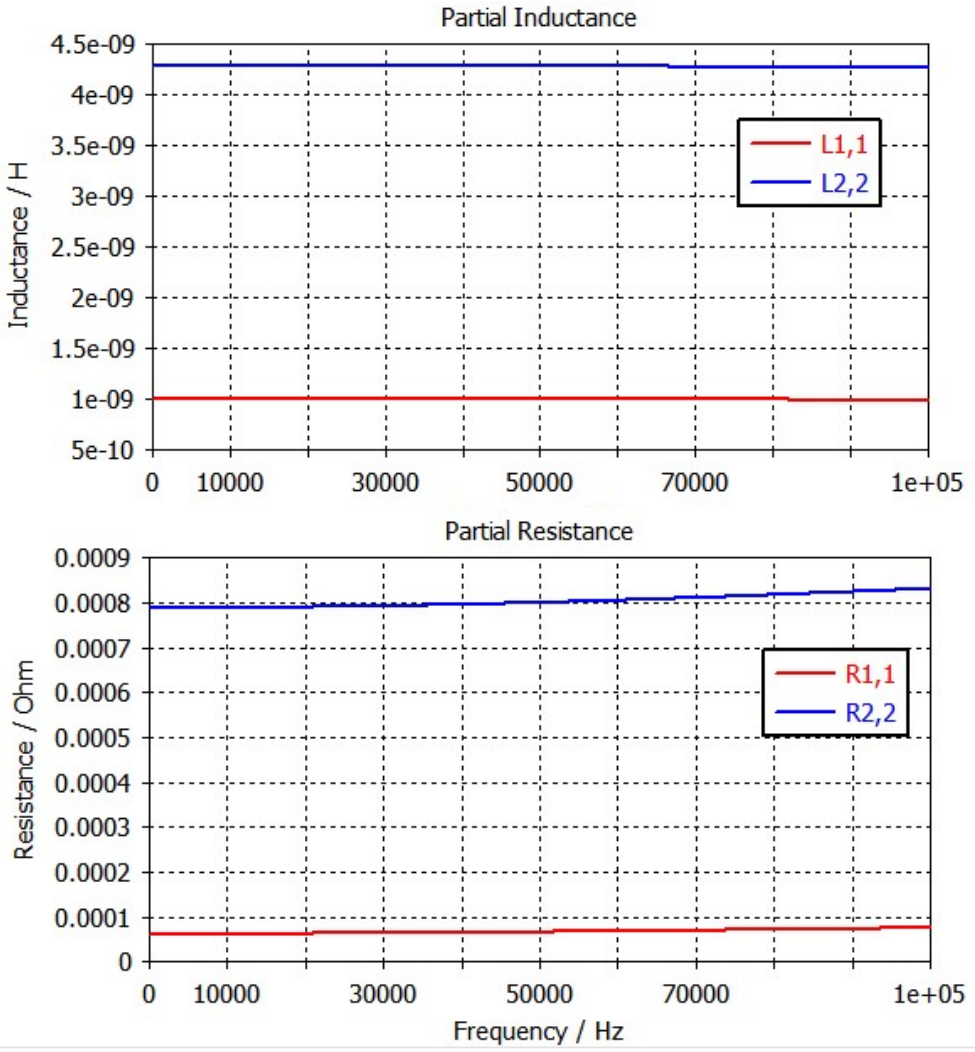
寄生参数



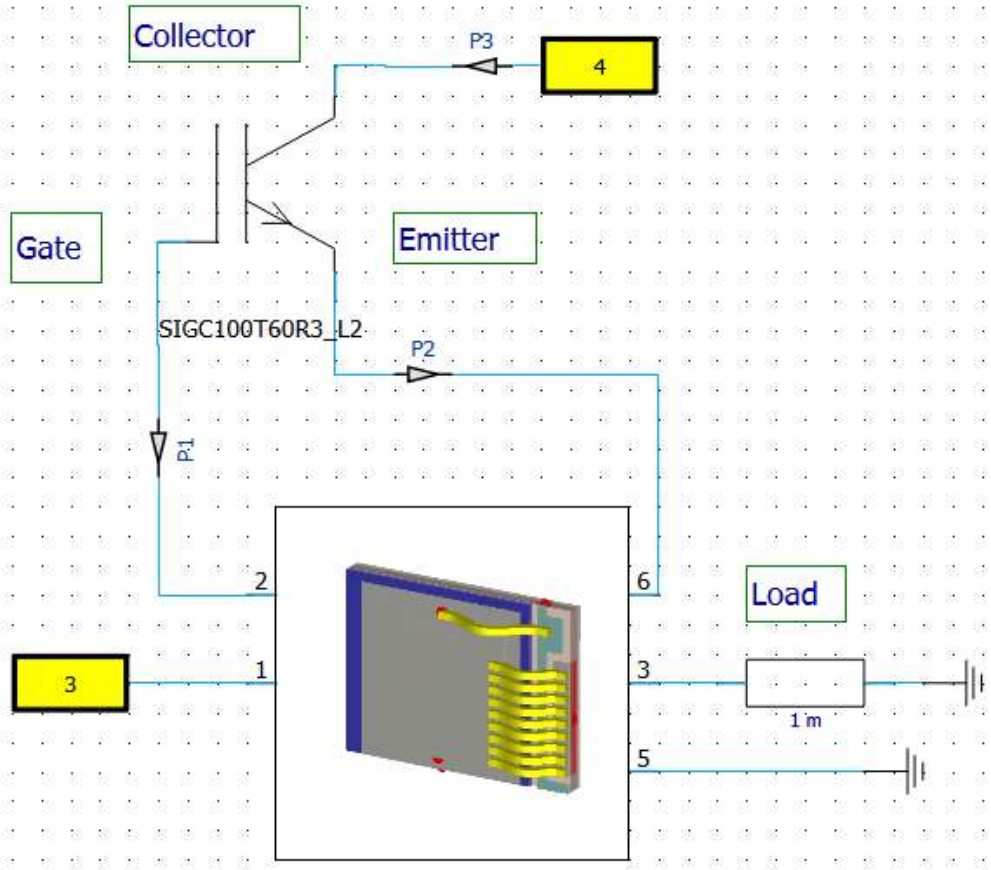


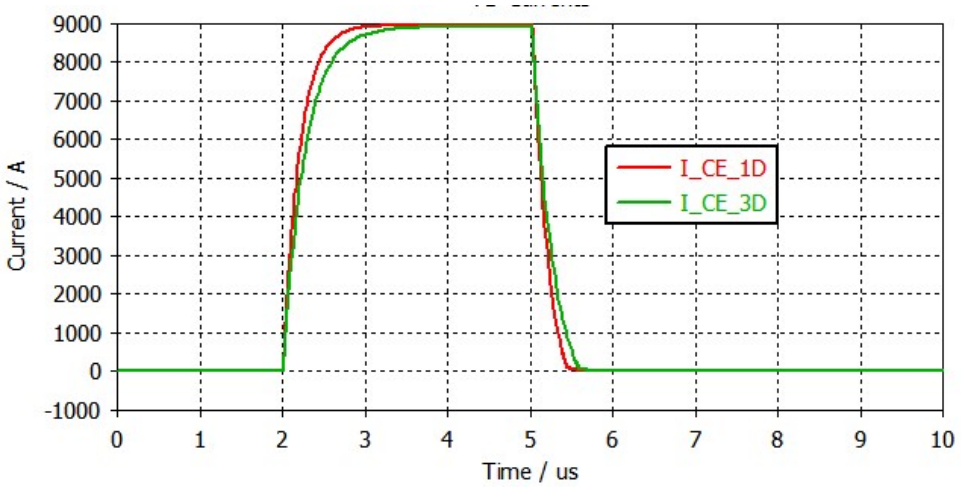
部分电感

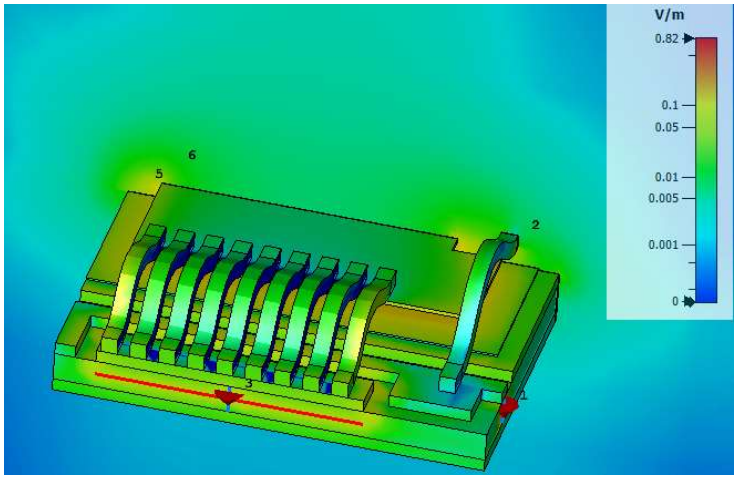




全三维协同仿真







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台架测试

传导发射

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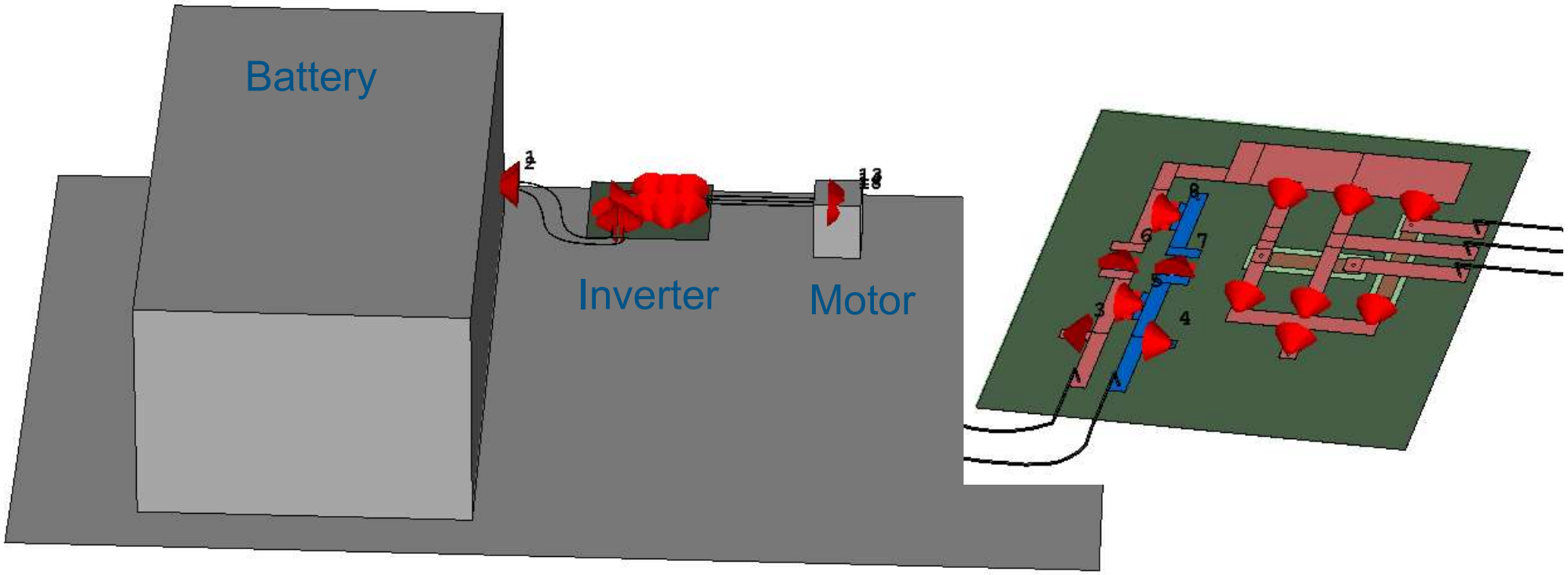
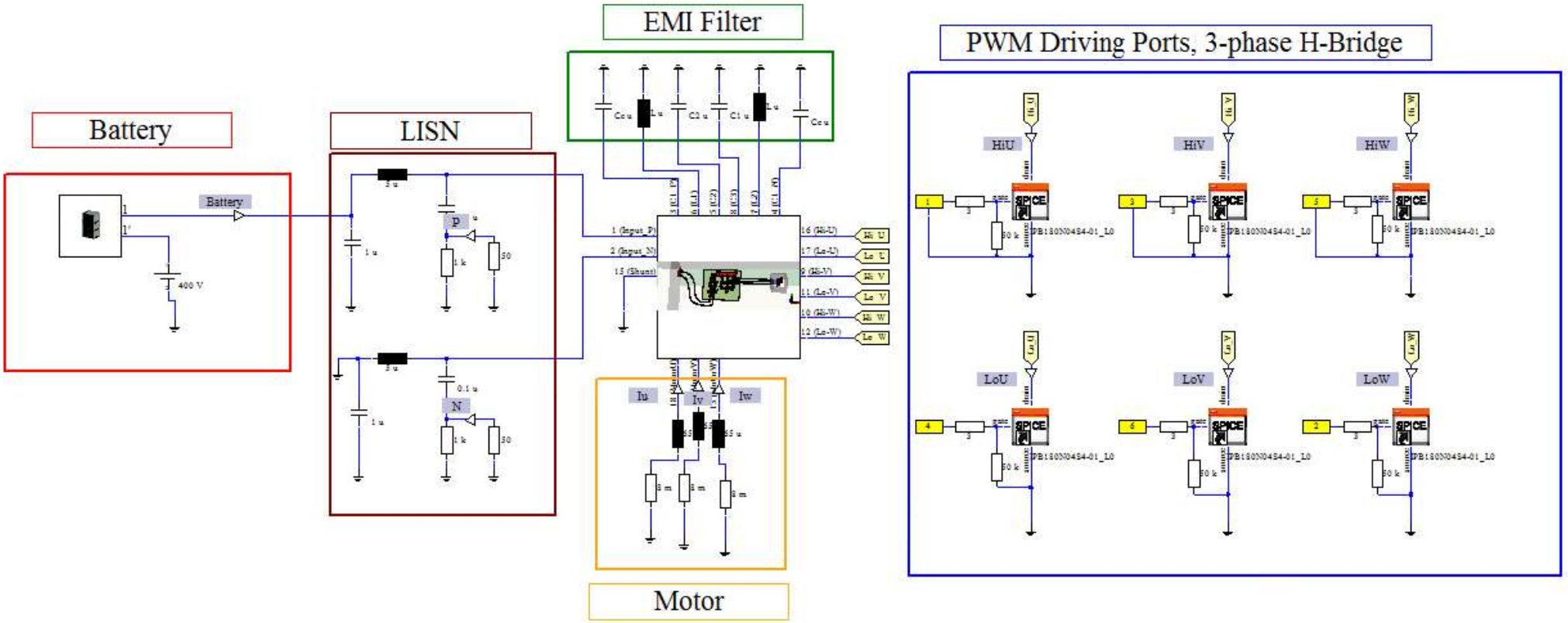
传动系统EMC台架测试

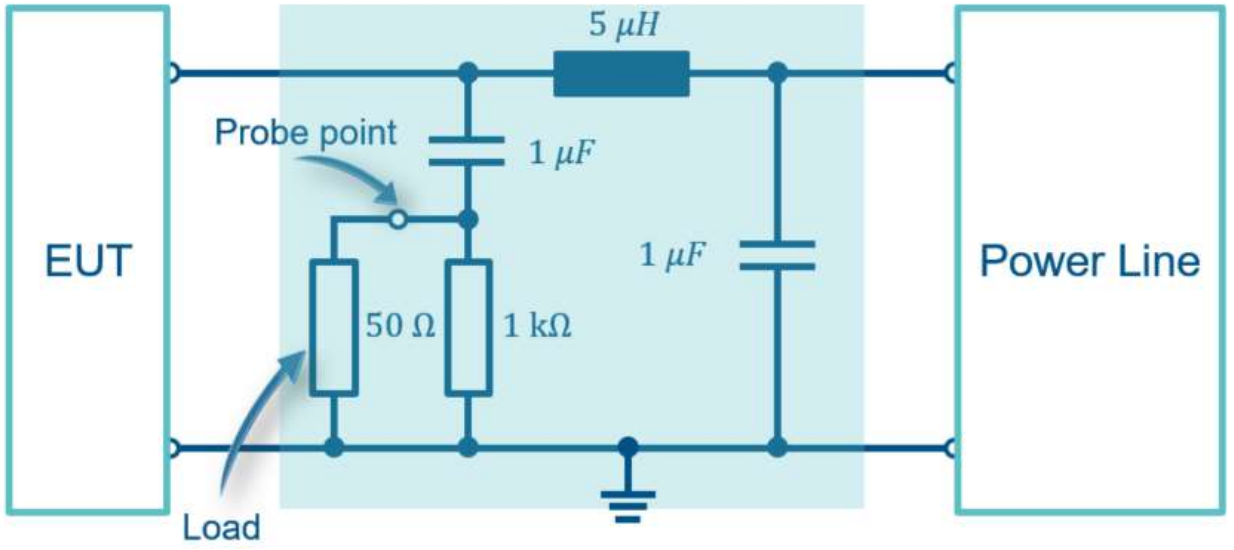


传动系统EMC台架测试



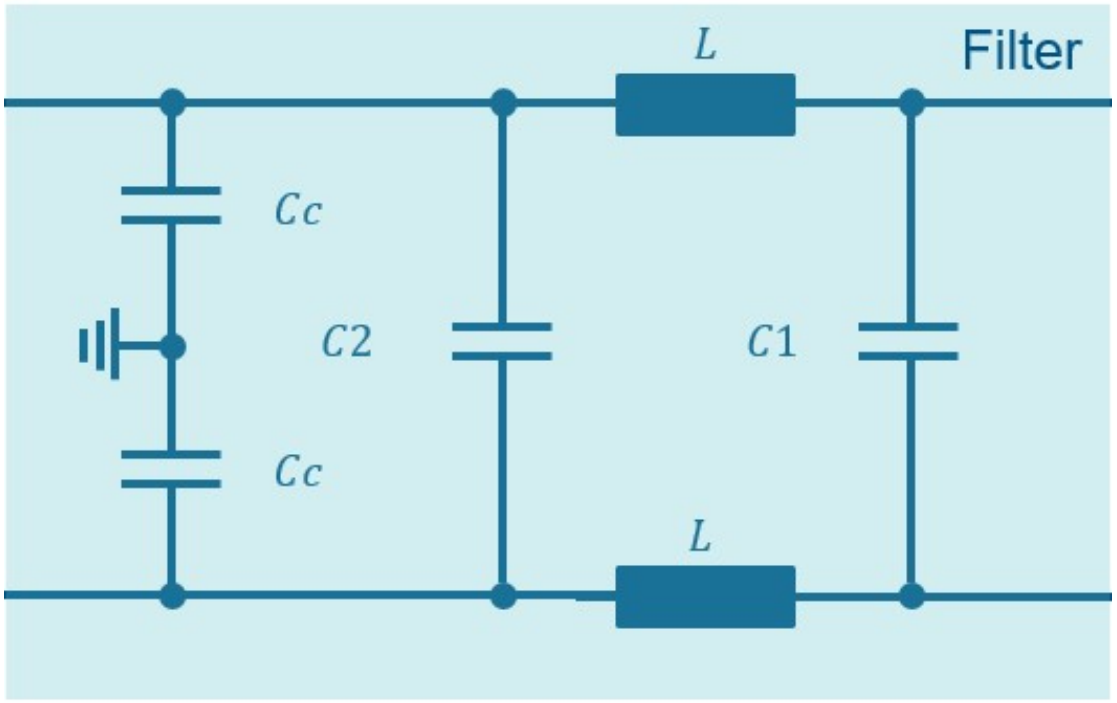
线路阻抗稳定网络(LISN)

- 测量传导发射，LISN(线路阻抗稳定网络)是必要的。
- 根据CISPR 25，LISN应该使用5 uH电感。
- 电路如下图。



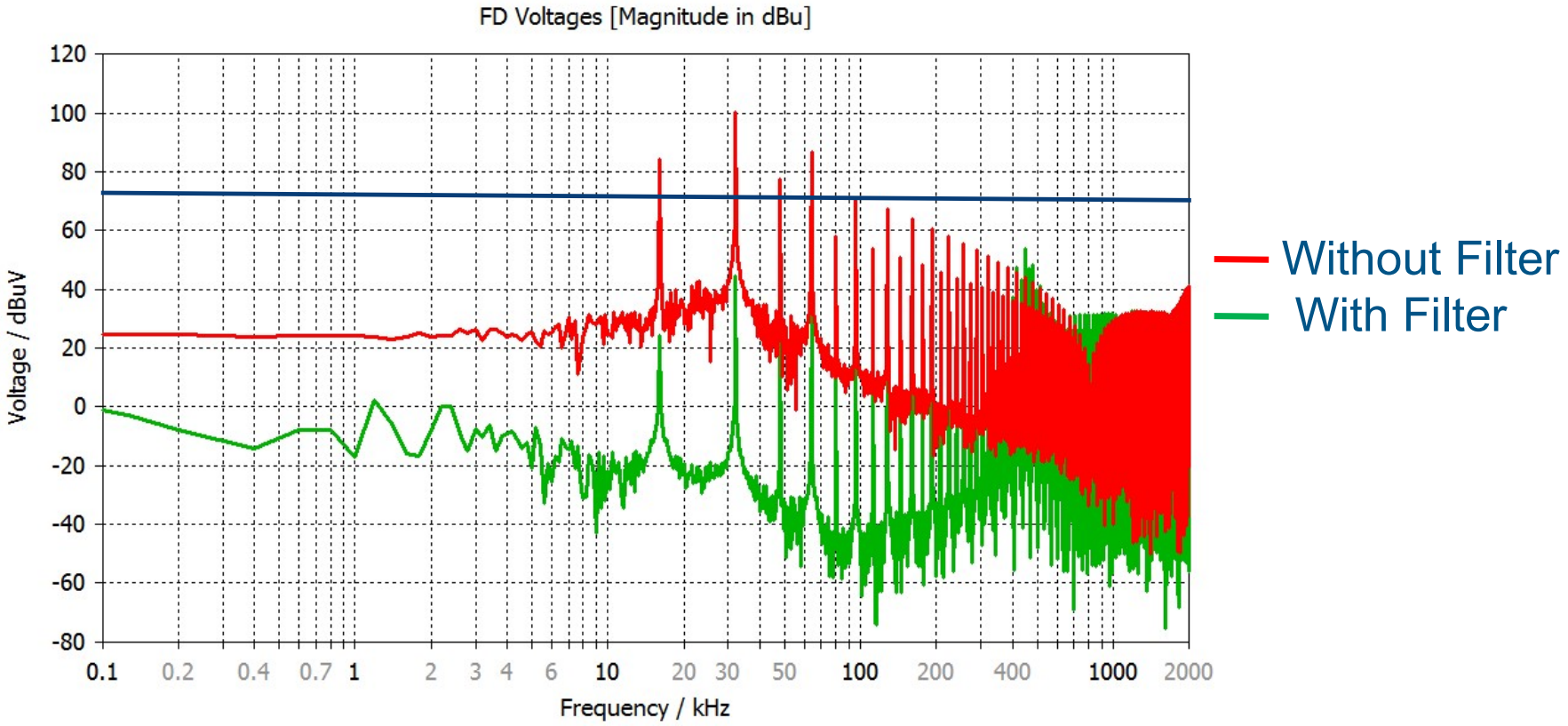
带滤波器的传导发射

所提出的滤波器设计用于去耦差模和共模电流噪声。

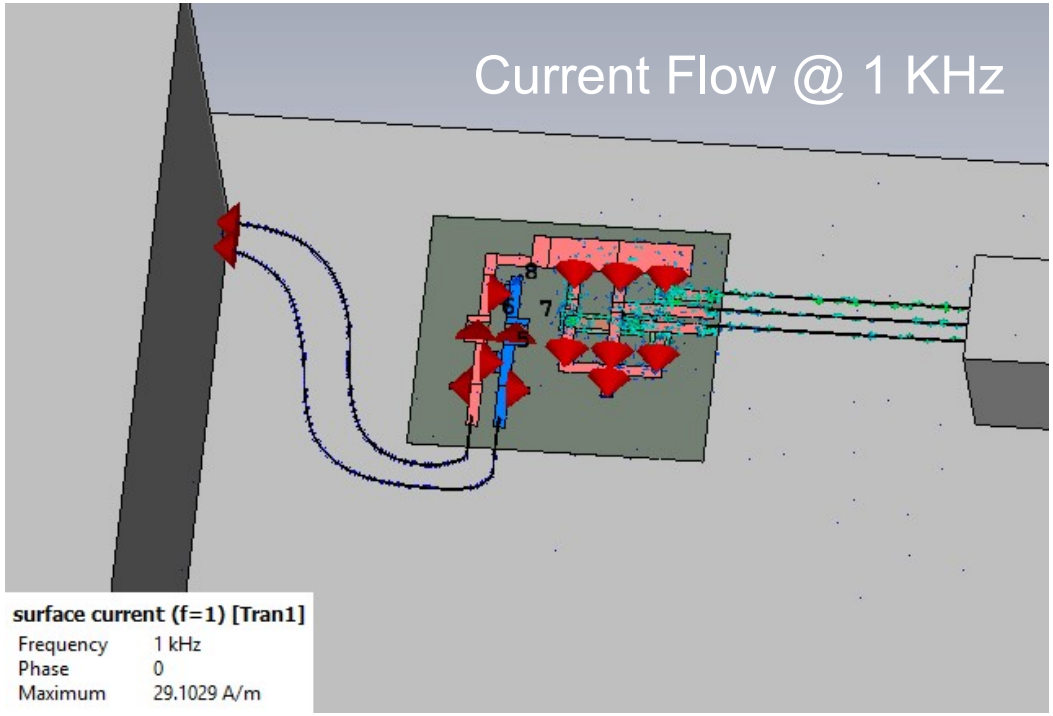


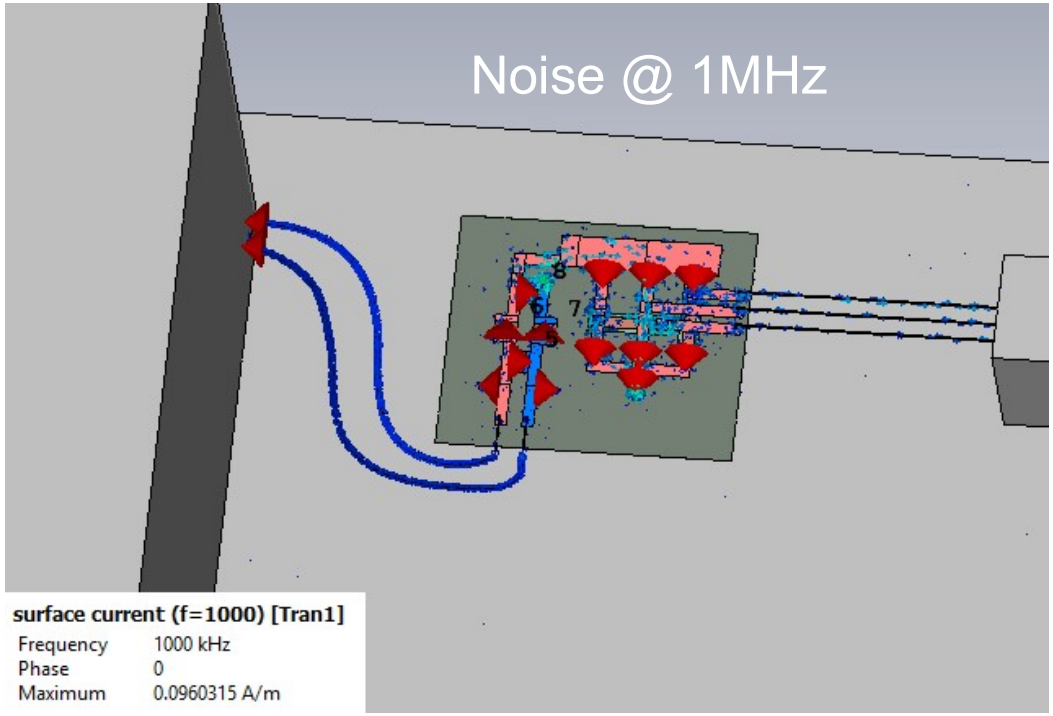
传导发射

CISPR 25: <76 dBuV for frequency lower than 300 kHz



电流分布





整车级仿真

共模分析

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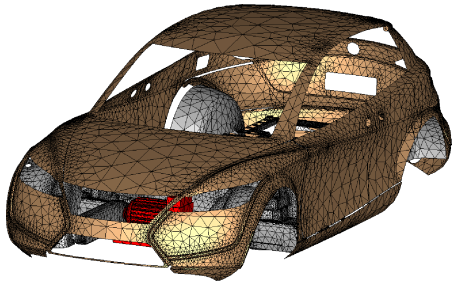
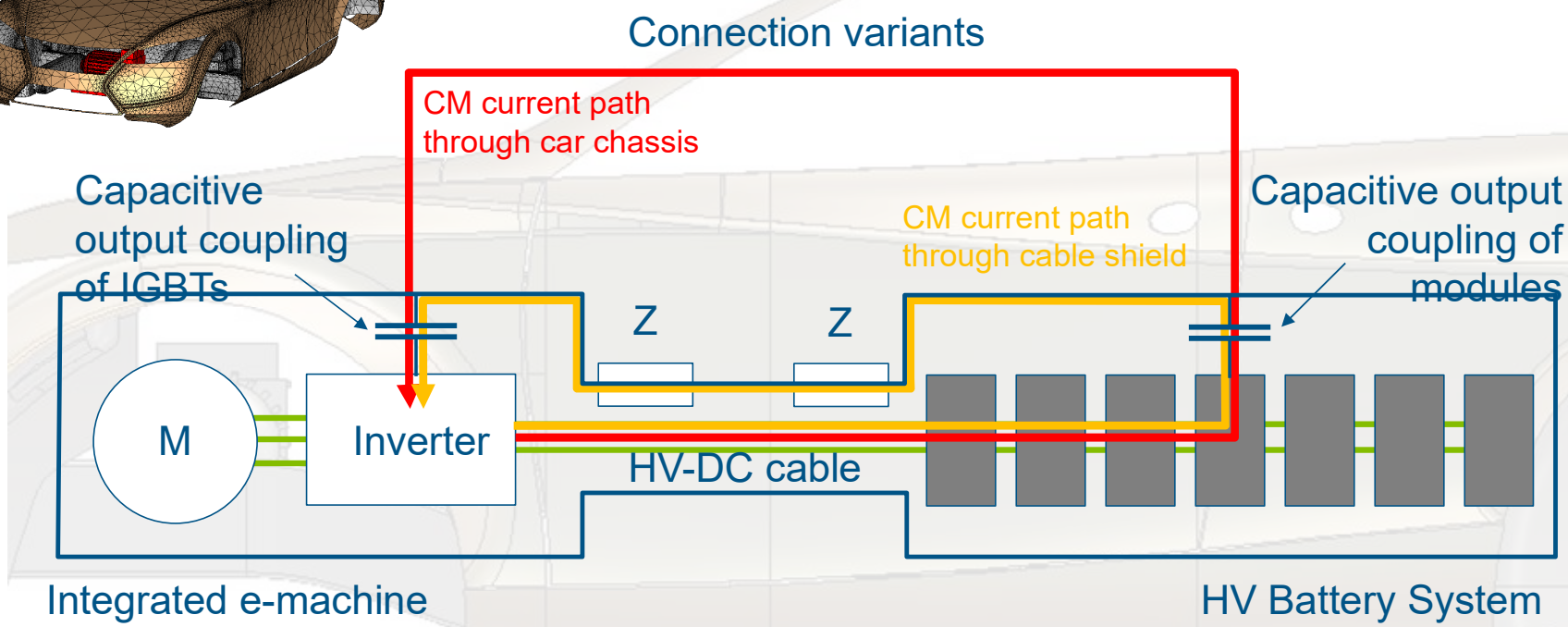
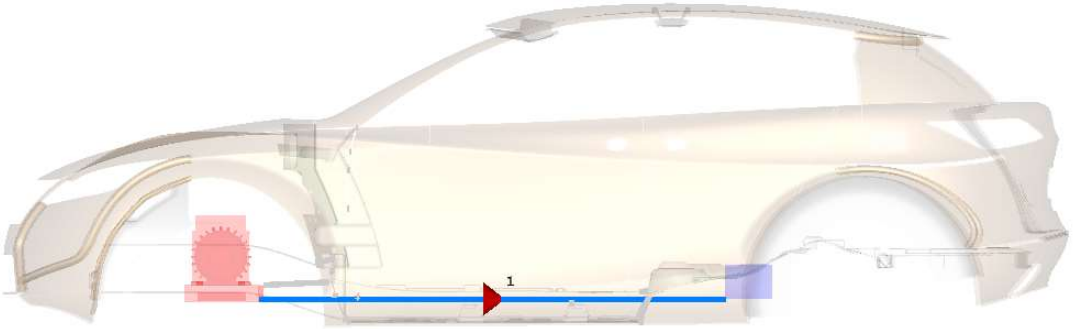
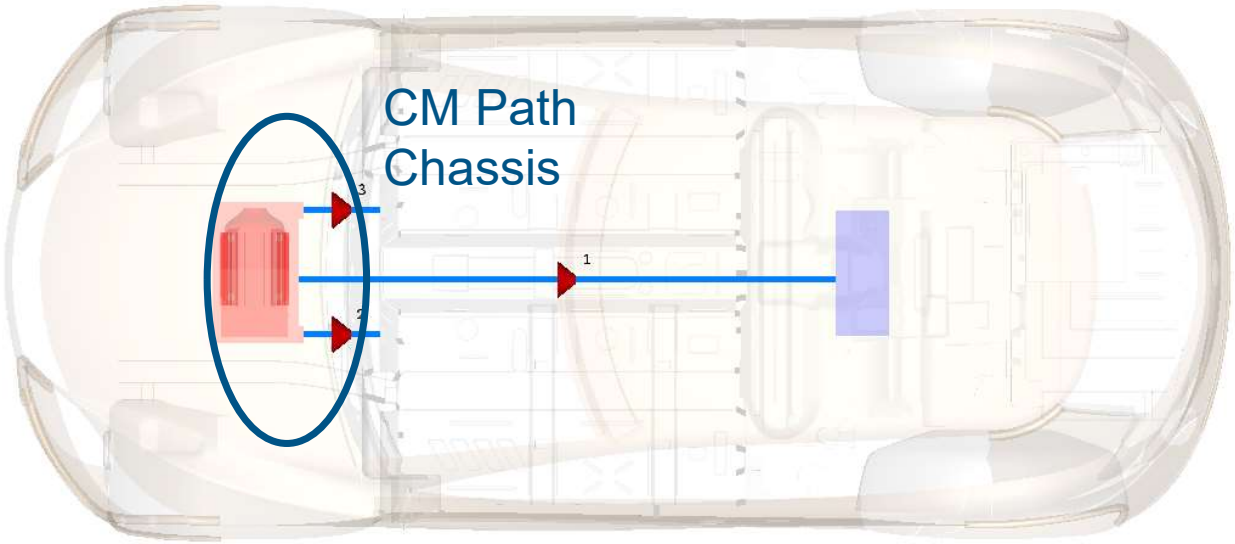
电动汽车中的共模电流路径



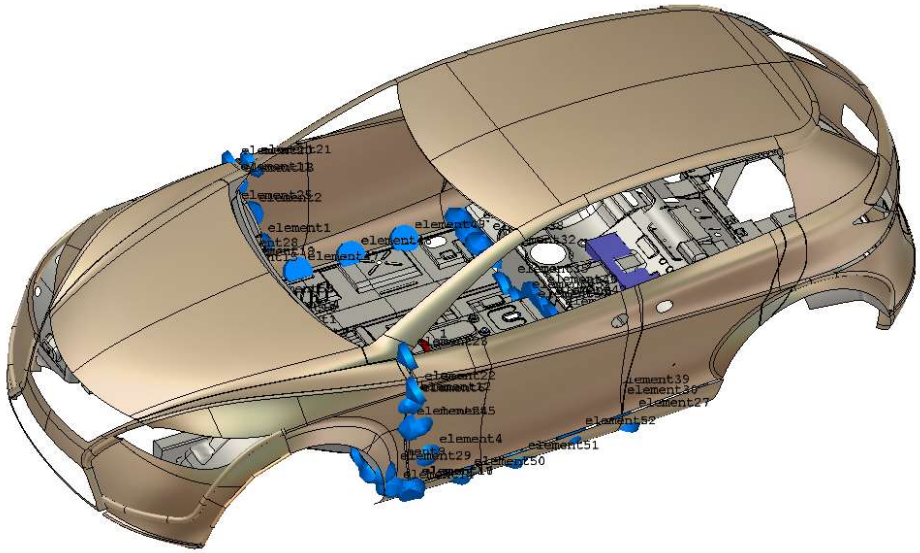


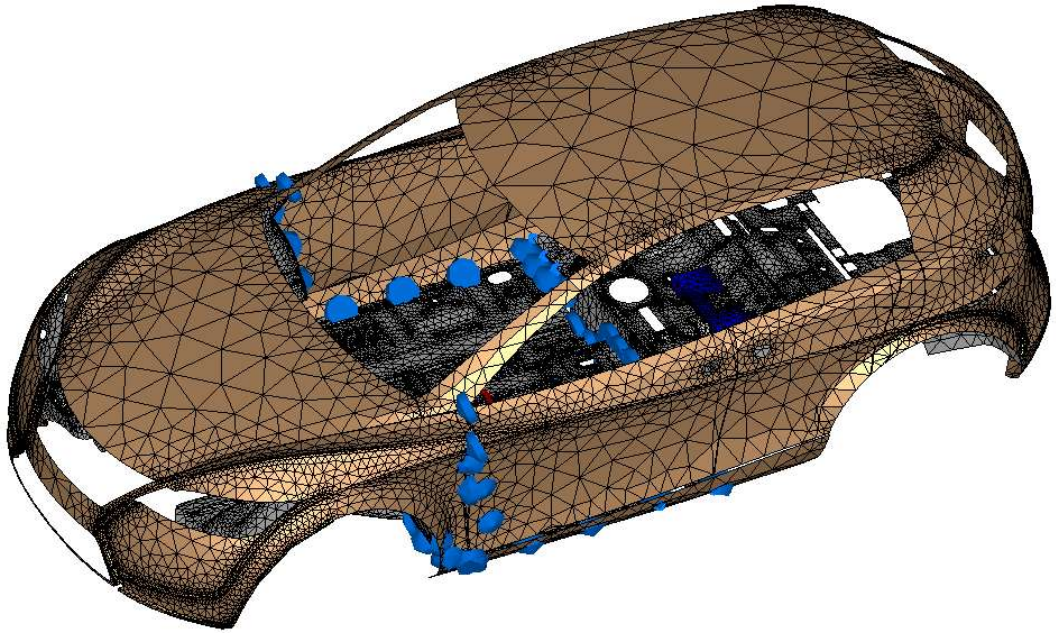
电动汽车中的共模电流路径





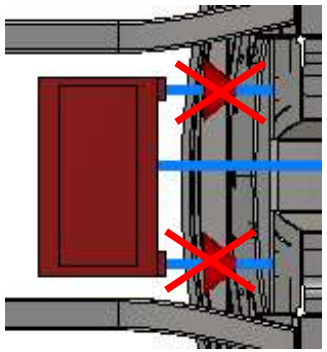
模型准备



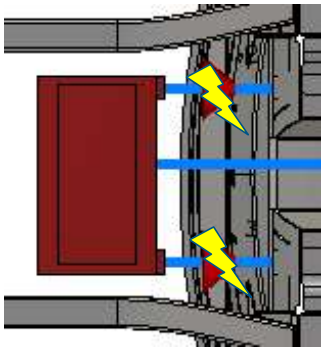


辐射电场

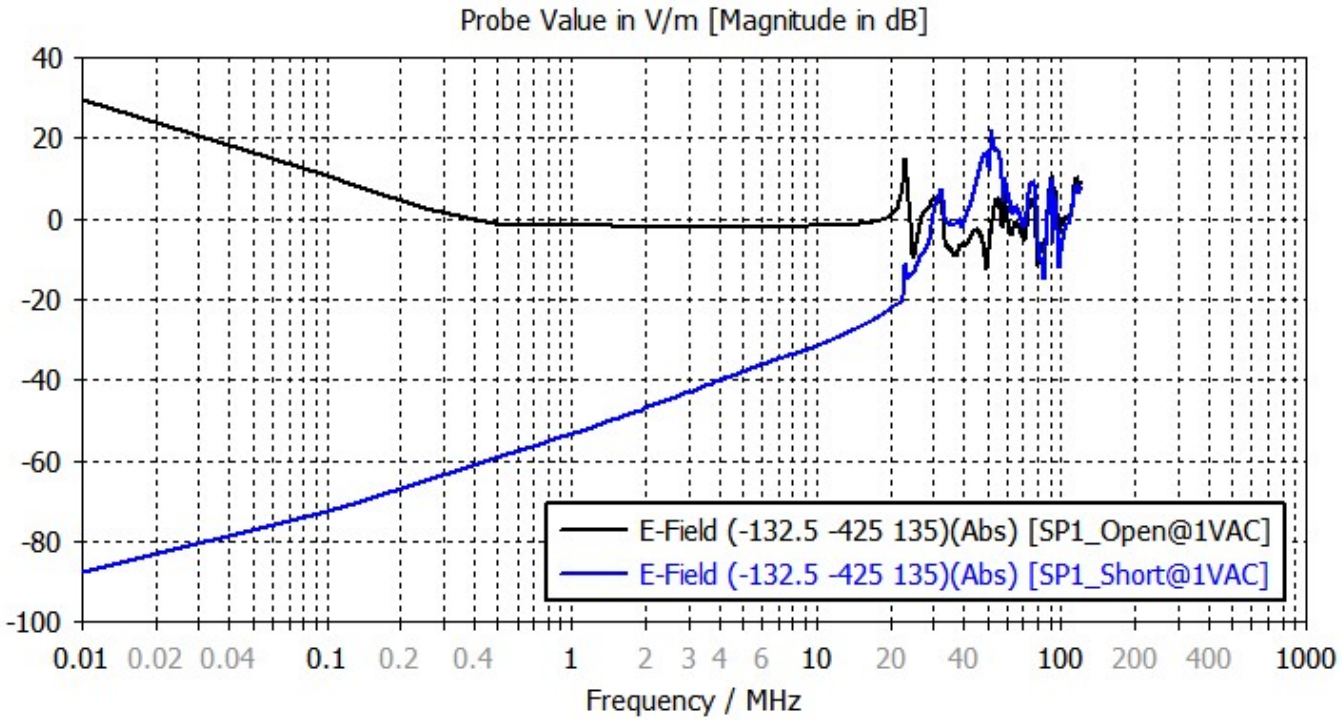
Open



Short



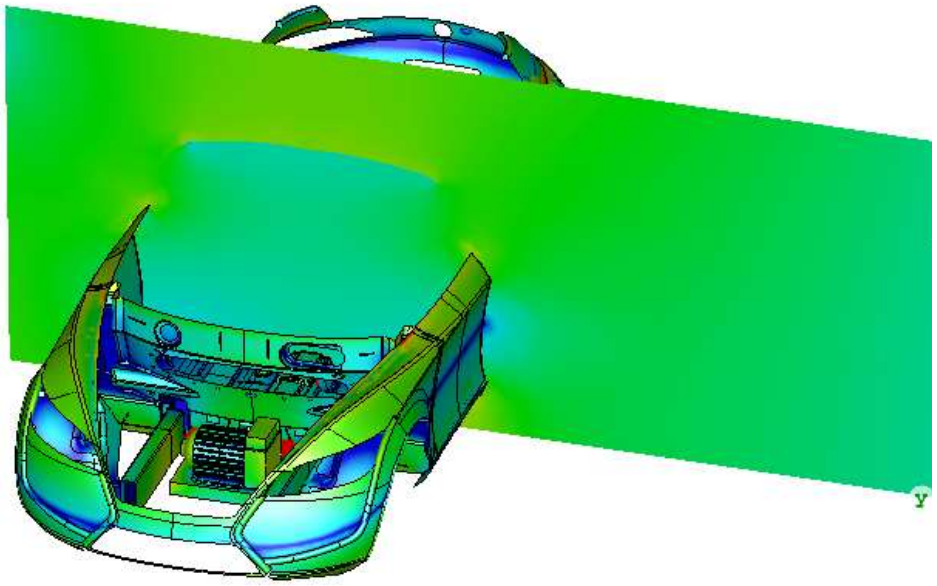
E-Field



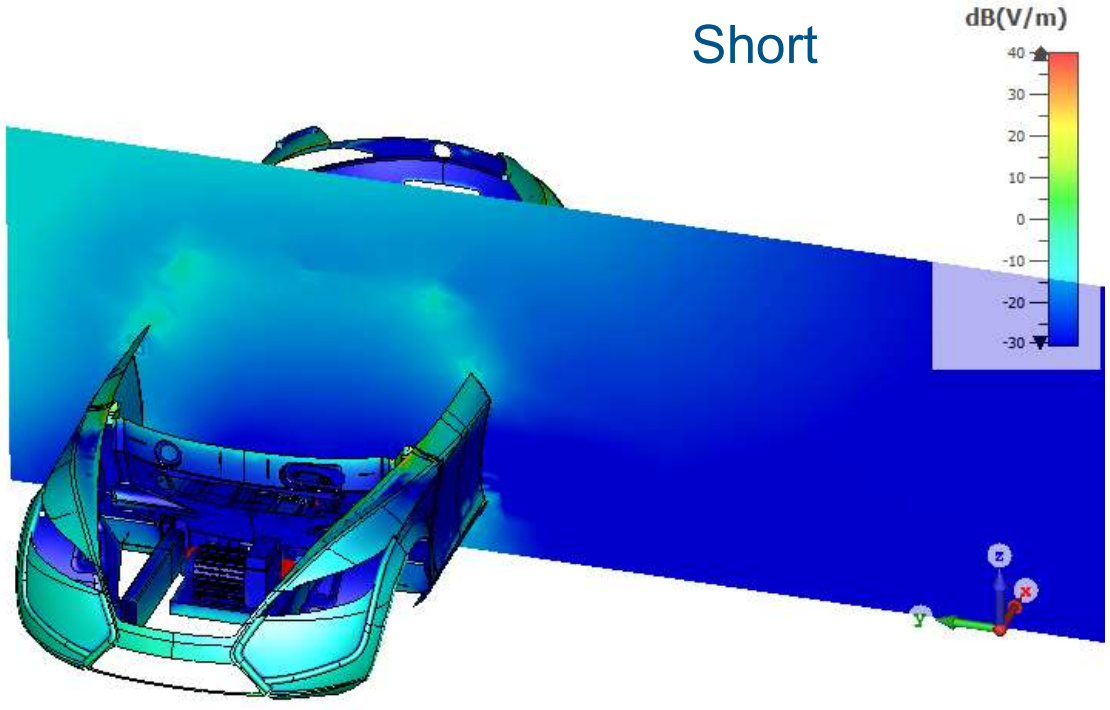
电场分布

- 12 MHz

Open



Short

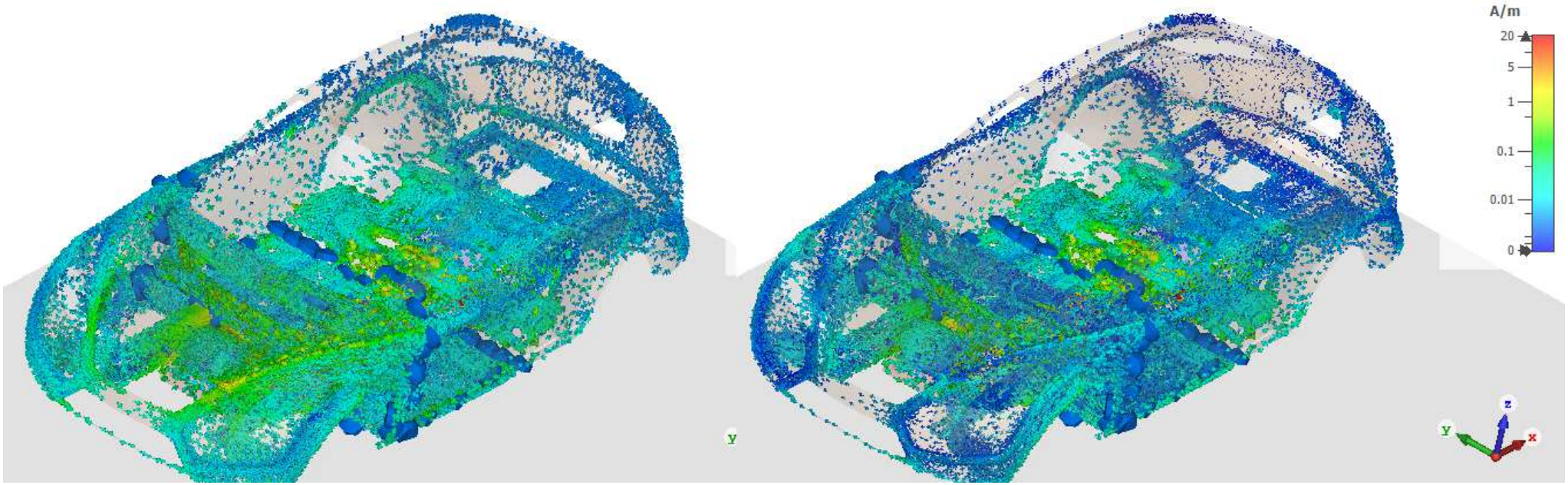


电流分布

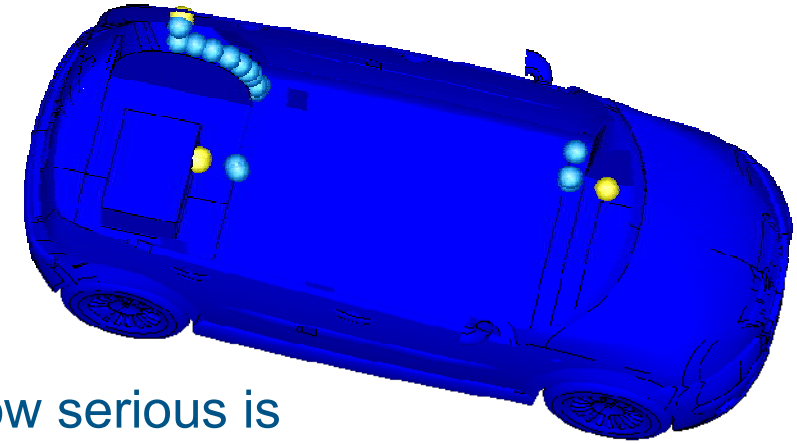
- 12 MHz

Open

Short



有关布线和电缆线束的问题



“How serious is the electromag emission?”

“Do we need shielded cables?”

“How can we reduce vehicle weight and labor cost?”

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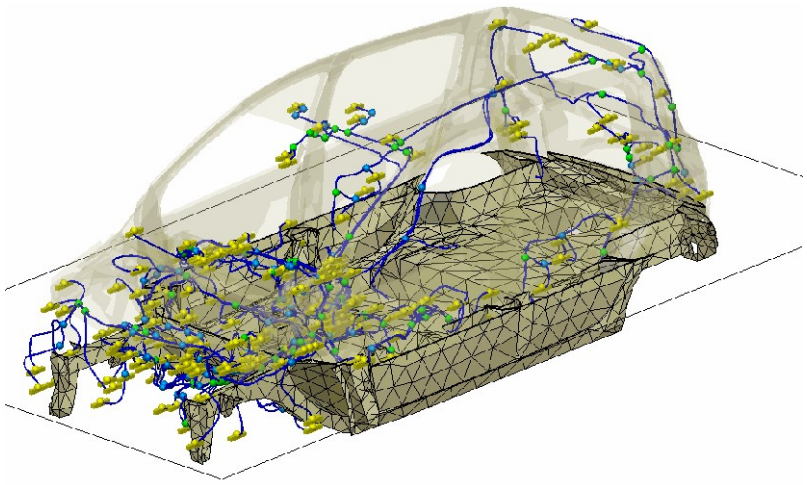
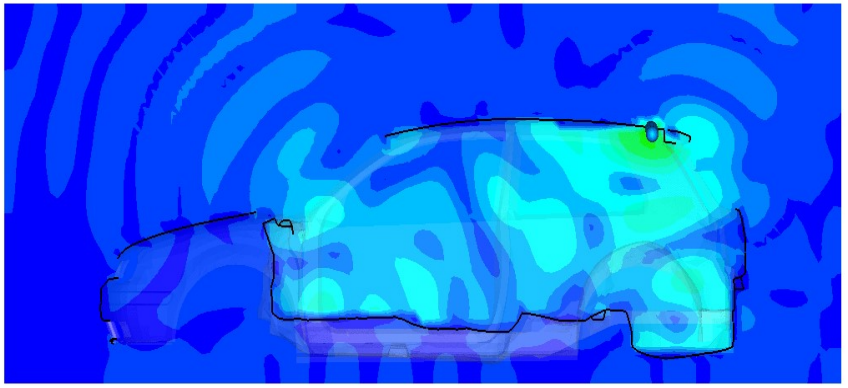
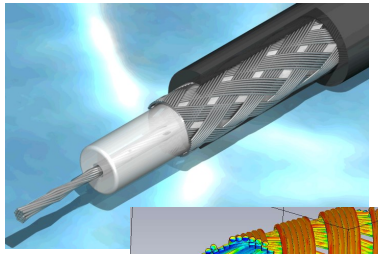
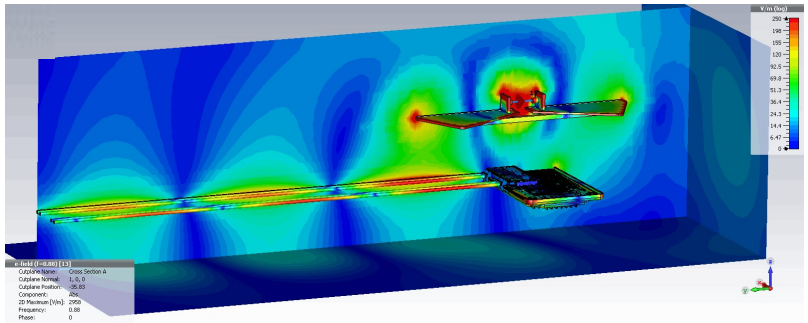
辐射发射/抗扰度

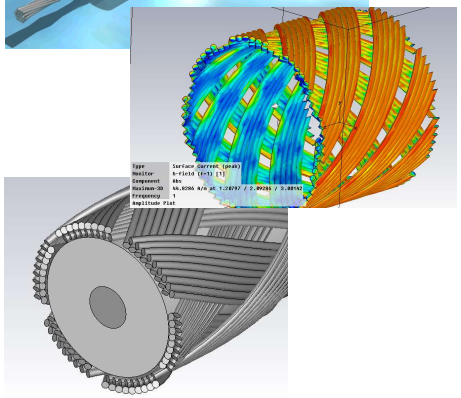


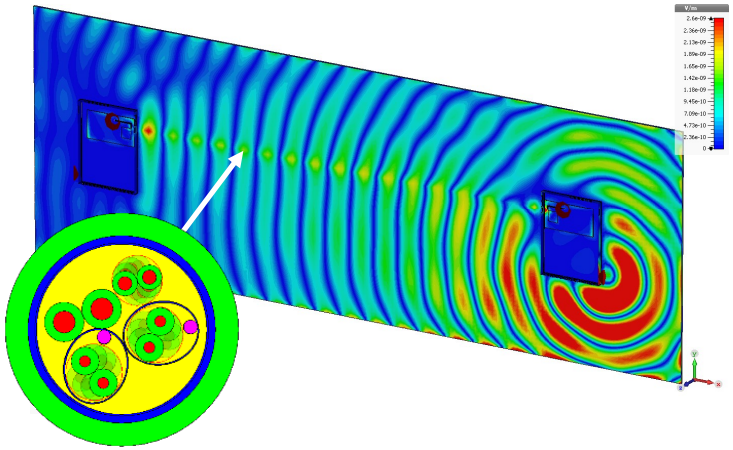
器件级 & 系统级分析











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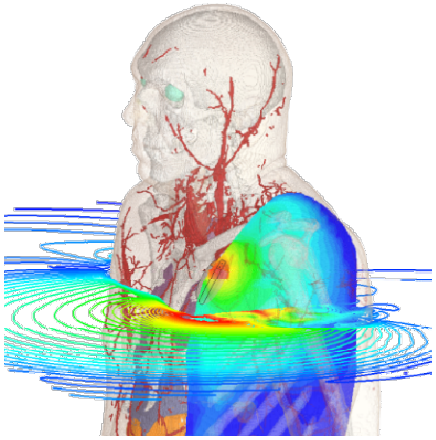
安全性:与高压相关的潜在风险

各种组织参与标准化和规范，为测量和仿真设置提供指导，并定义限值

国际非电离辐射防护委员会（ICNIRP）

IEC、IEEE、当地标准化机构

当地法规，例如欧洲指令2013-35 EU“关于工人暴露于物理因素(电磁场)风险的最低健康和安全要求”



Potential risks are:

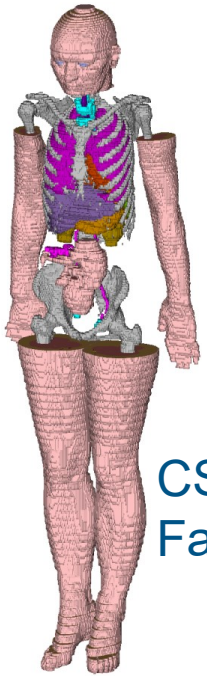
- Electric energy
- Accidental arcs
- Electric current flowing through the body (electric shock)
- Electromagnetic fields affecting e.g. pacemakers
- Interactions between electric energy and other media

人体仿真模型

正确选择生物模型对于生物电磁仿真的可靠性至关重要

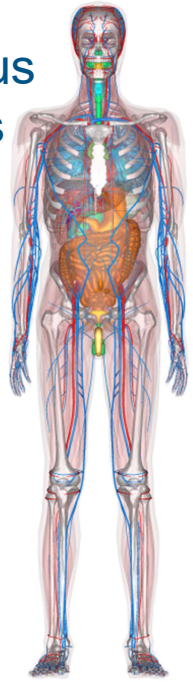
解剖细节:

Homogeneous models



CST Voxel Family

Heterogeneous CAD models

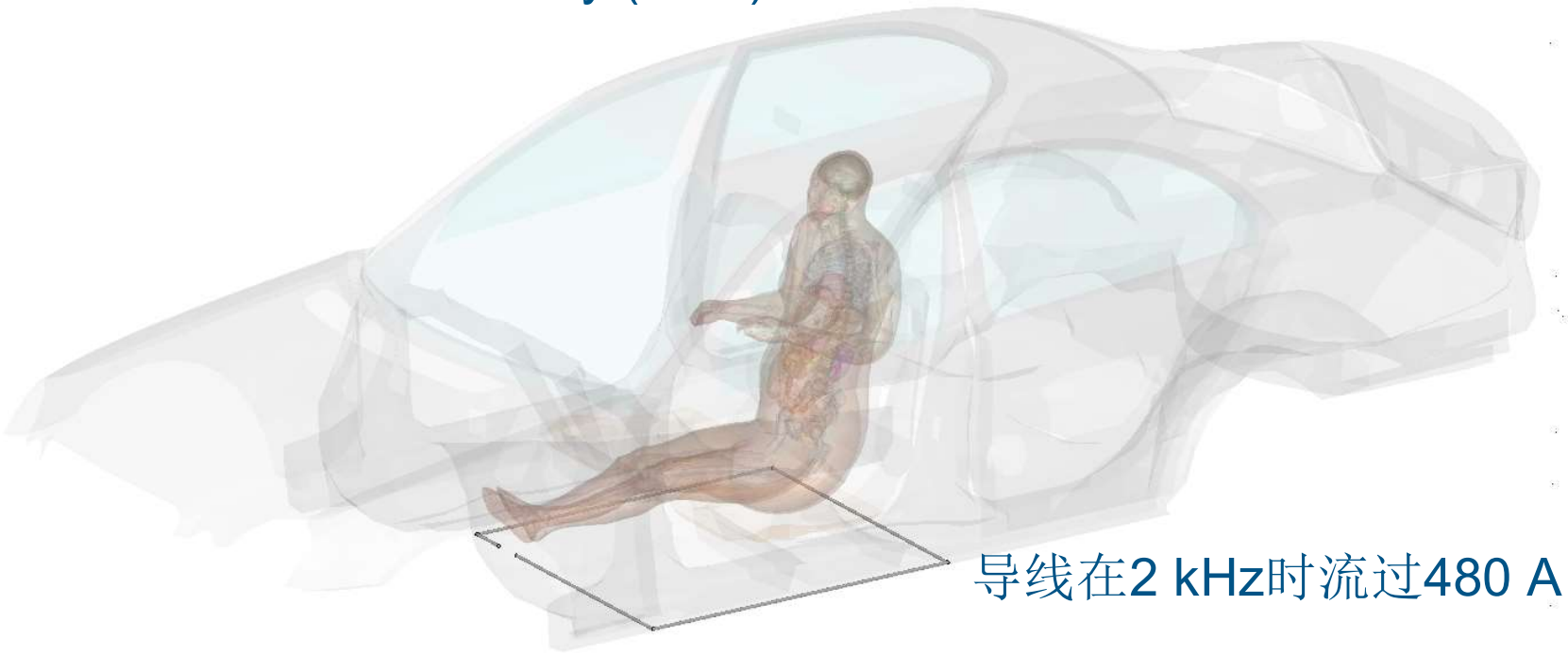


材料属性:

- 频率相关的电磁特性 (4Cole-Cole模型)
- 温度相关的电磁特性
- 依赖于温度的热特性

高牵引电流下的驾驶员安全

用透明阻抗片建模汽车底盘
基于异构CAD的人体模型Nelly (VHP)



导线在2 kHz时流过480 A的牵引电流

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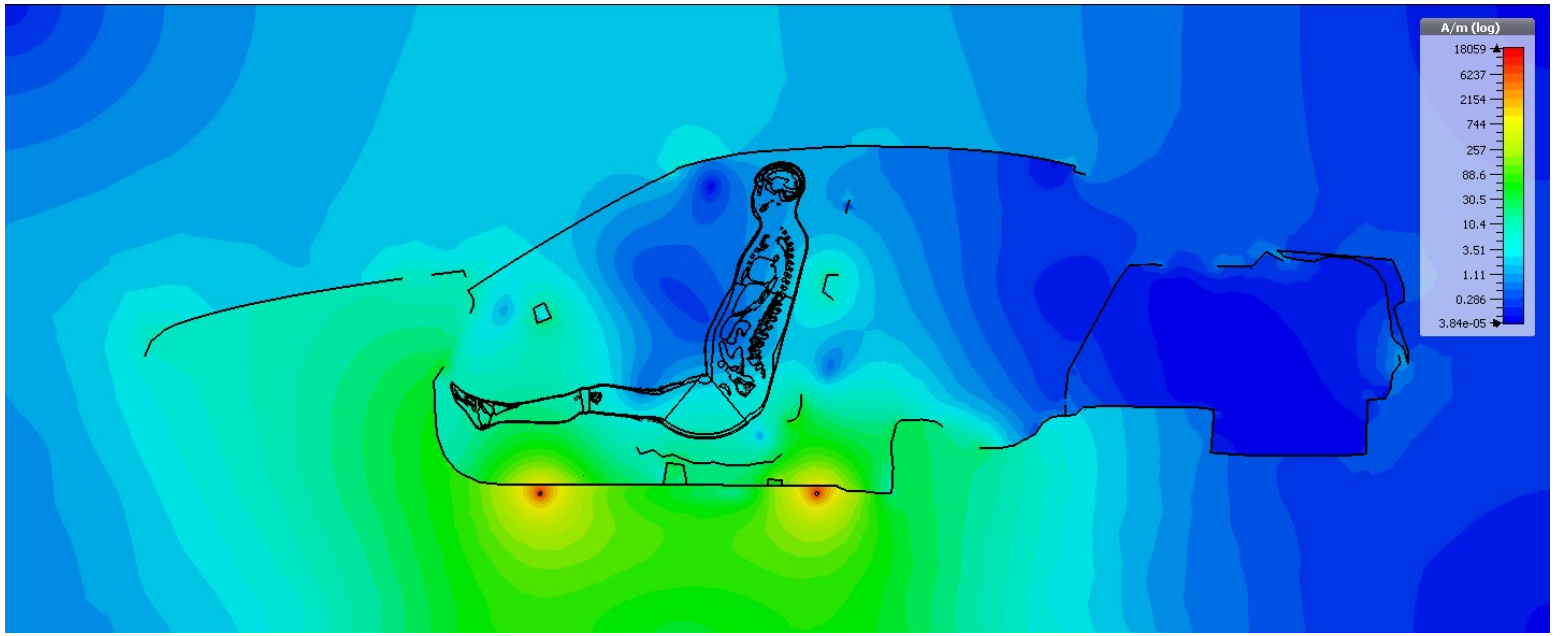
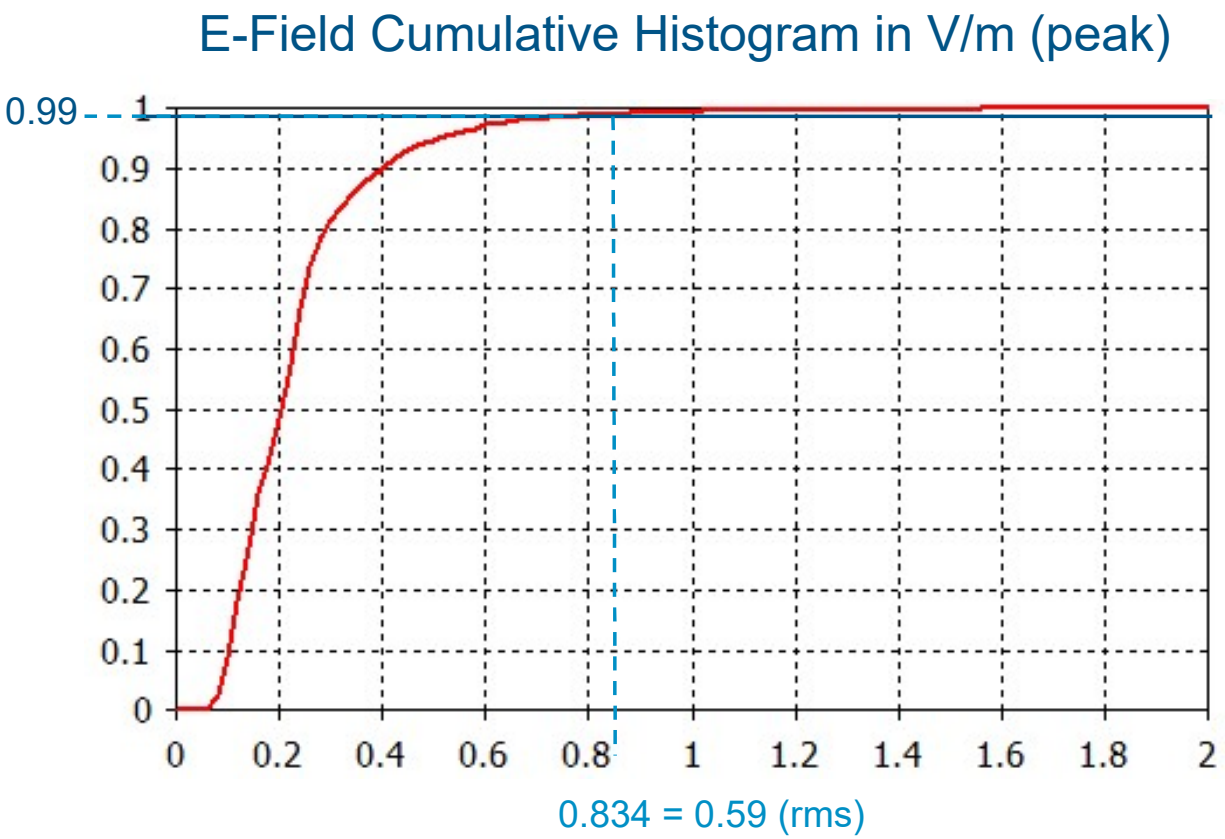
高牵引电流下的驾驶员安全



牵引电流的合规



人体暴露基本限制在2 kHz (ICNIRP)

- 职业暴露: 0.8 V/m
- 一般公共暴露: 0.4 V/m

第99百分位为0.59 V/m（均方根），高于一般接触限值。但是：峰值电流高，需要考虑平均值！

总结

- 仿真对于电动汽车的创新起着至关重要的作用。
- 仿真可以在不同的层次上进行
  - 部件、电机设计、电池和逆变器
  - EMC/EMI台架测试
  - 整车仿真
- 仿真可以深入了解与发射有关的问题。

- SIMULIA提供标准解决方案和定制工程服务

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