IDAJ公司

48V动力总成振动分析

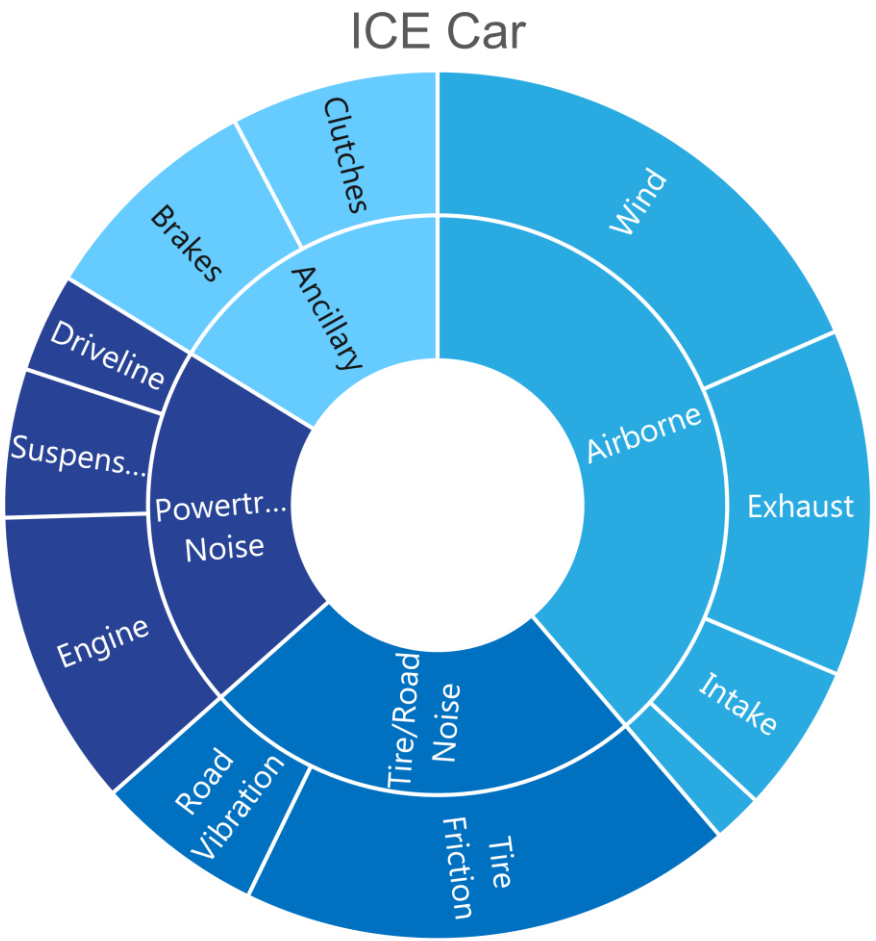
IDAJ中国

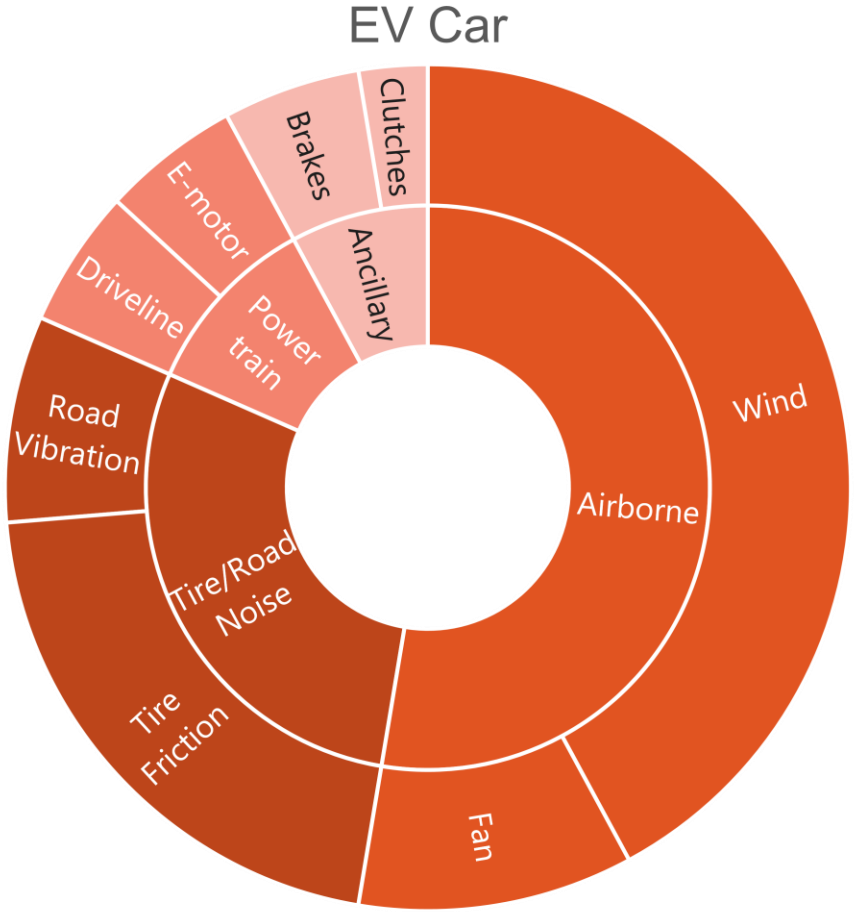
GT小组

目录

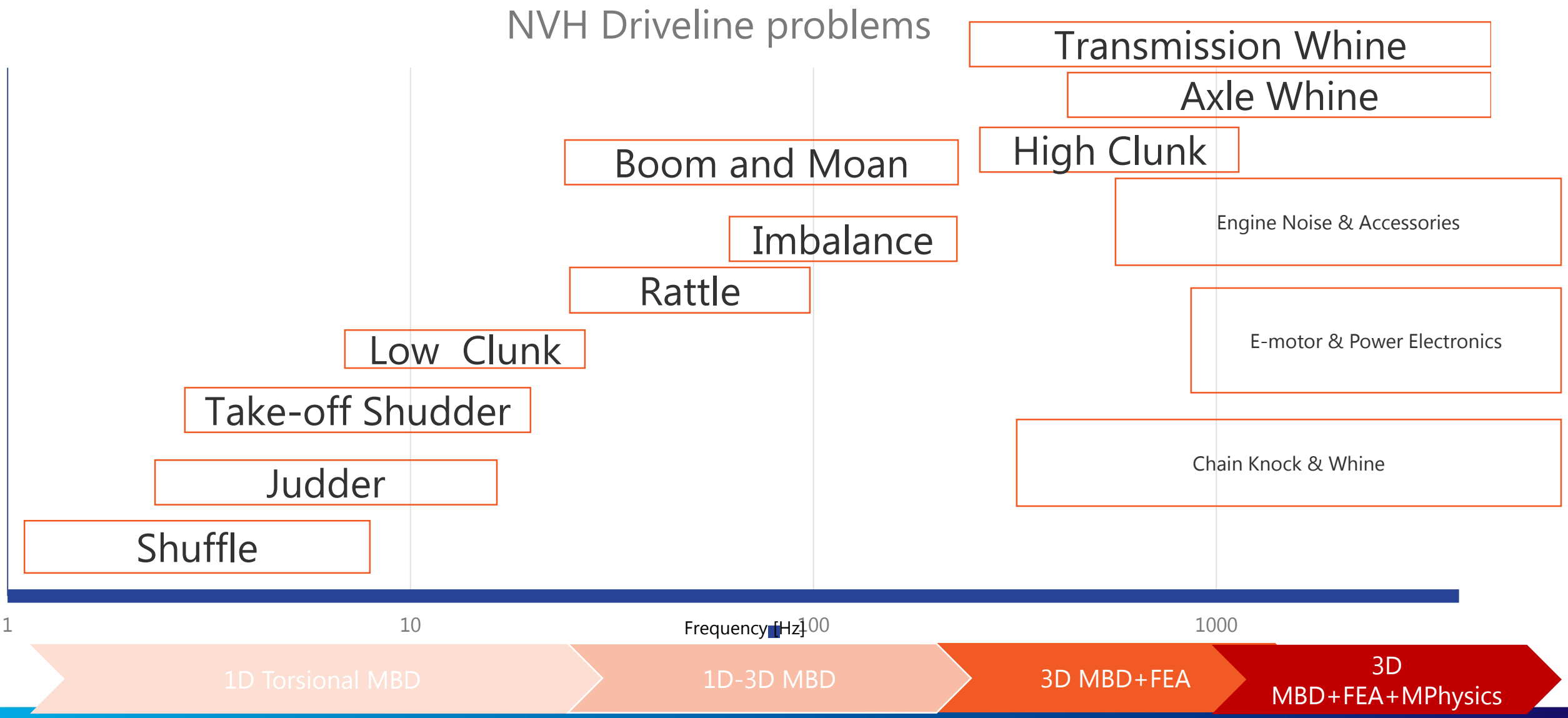
简介:新的振动源

- 电气化“揭露”了动力系统机械噪音的新来源
- 低速时问题严重

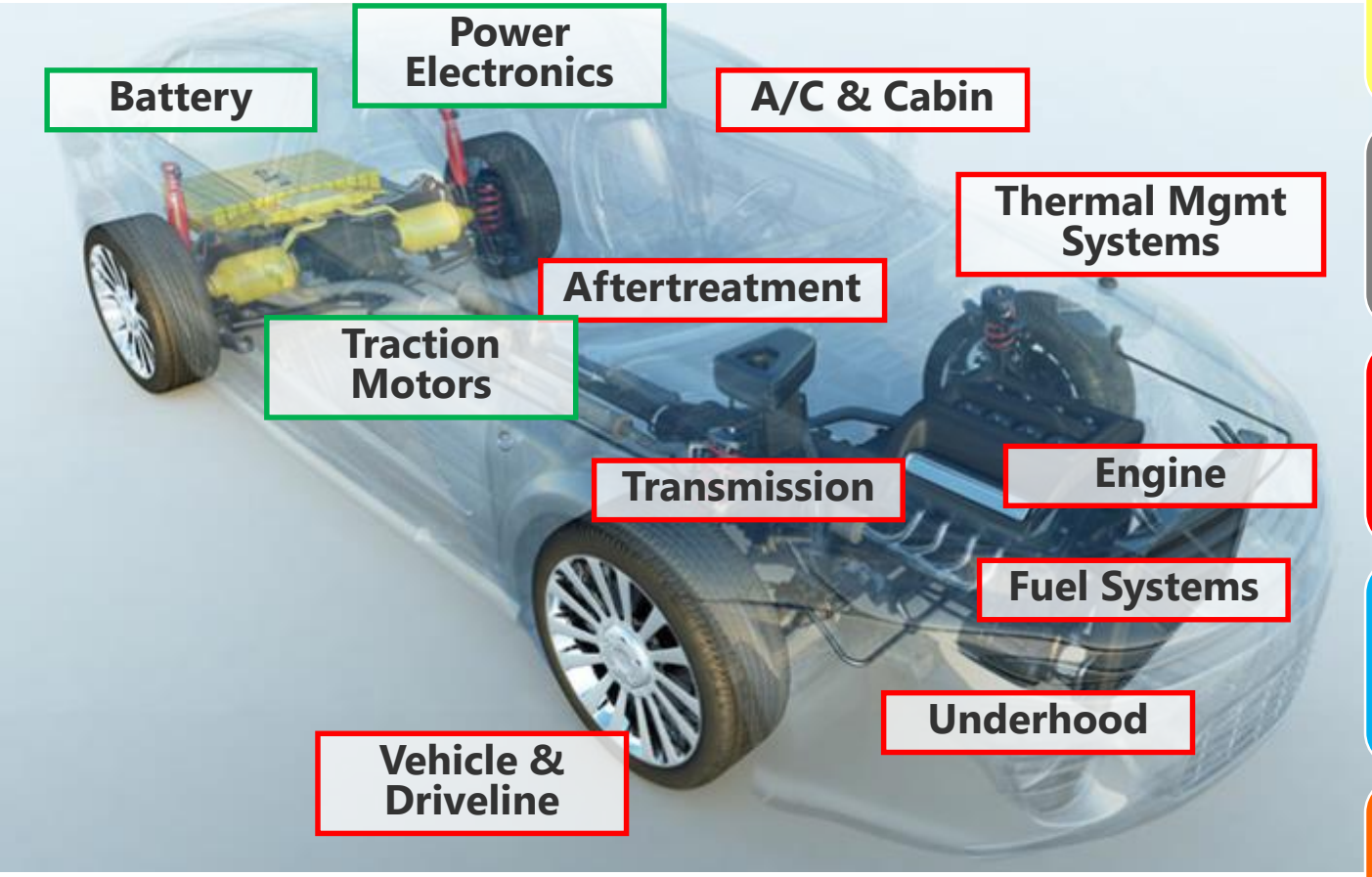




简介：xEVs动力系统中的常见问题



简介：系统相互作用



Flow

- Engine (Air)
- Underhood (Air)
- Fuel Systems (G/D)
- Coolant
- Refrigerant
- Eng & Trans. Oil

Mechanical

- Engine
- Transmission
- Driveline & Vehicle
- **Battery**
- **Power Electronics**
- **Electric Machines**

Thermal

- Engine
- Transmission
- Underhood
- Cabin
- **Battery**
- **Power Electronics**
- **Electric Machines**

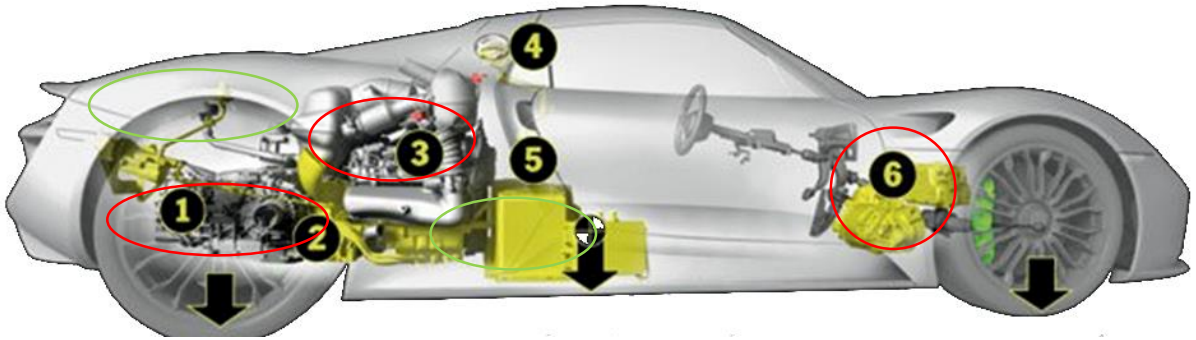
Chemical

- Combustion
- Aftertreatment
- **Battery**
- **Fuel Cell**

Electrical

- **Battery**
- **Power Electronics**
- **Electric Machines**

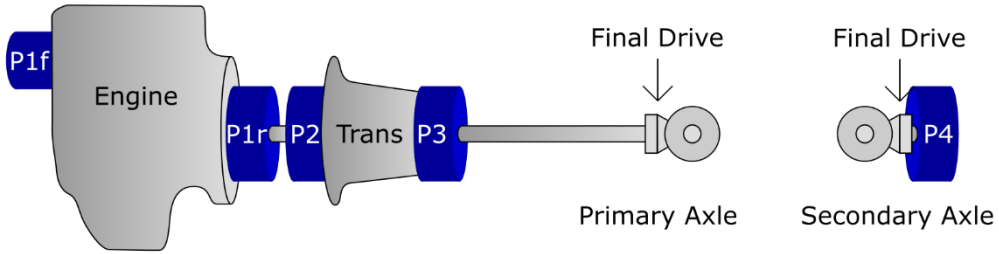
简介: 系统相互作用、控制优化



Power Actuators

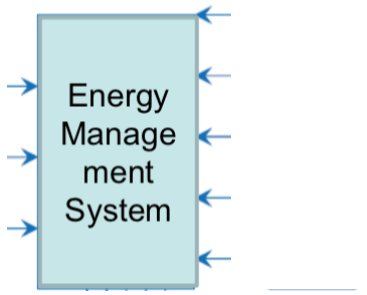
Energy Sources

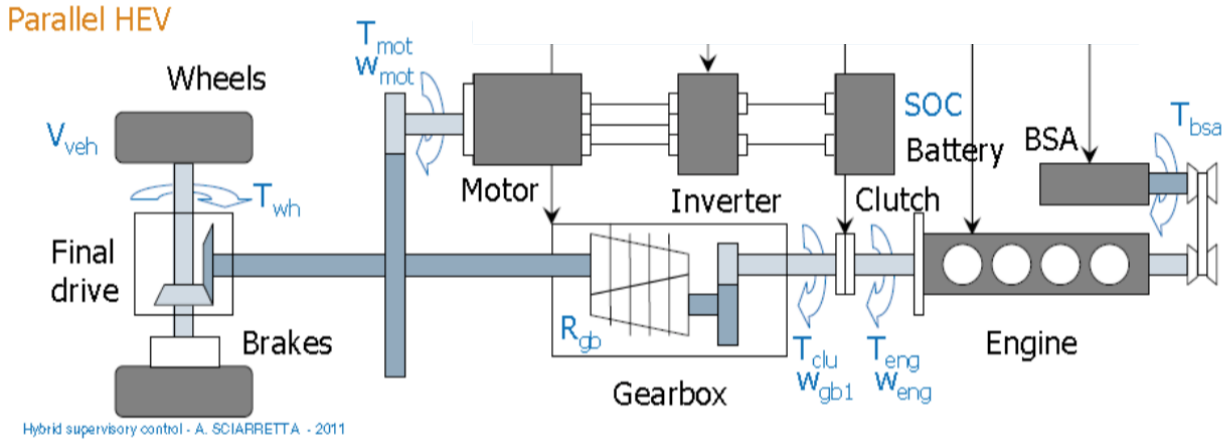
Definition of a Proper Architecture



简介：系统相互作用、控制优化

- 能源管理系统定义了电源之间的运行模式和功率分配策略





High-level tasks ➔ energy optimization, battery SOC control, etc.)

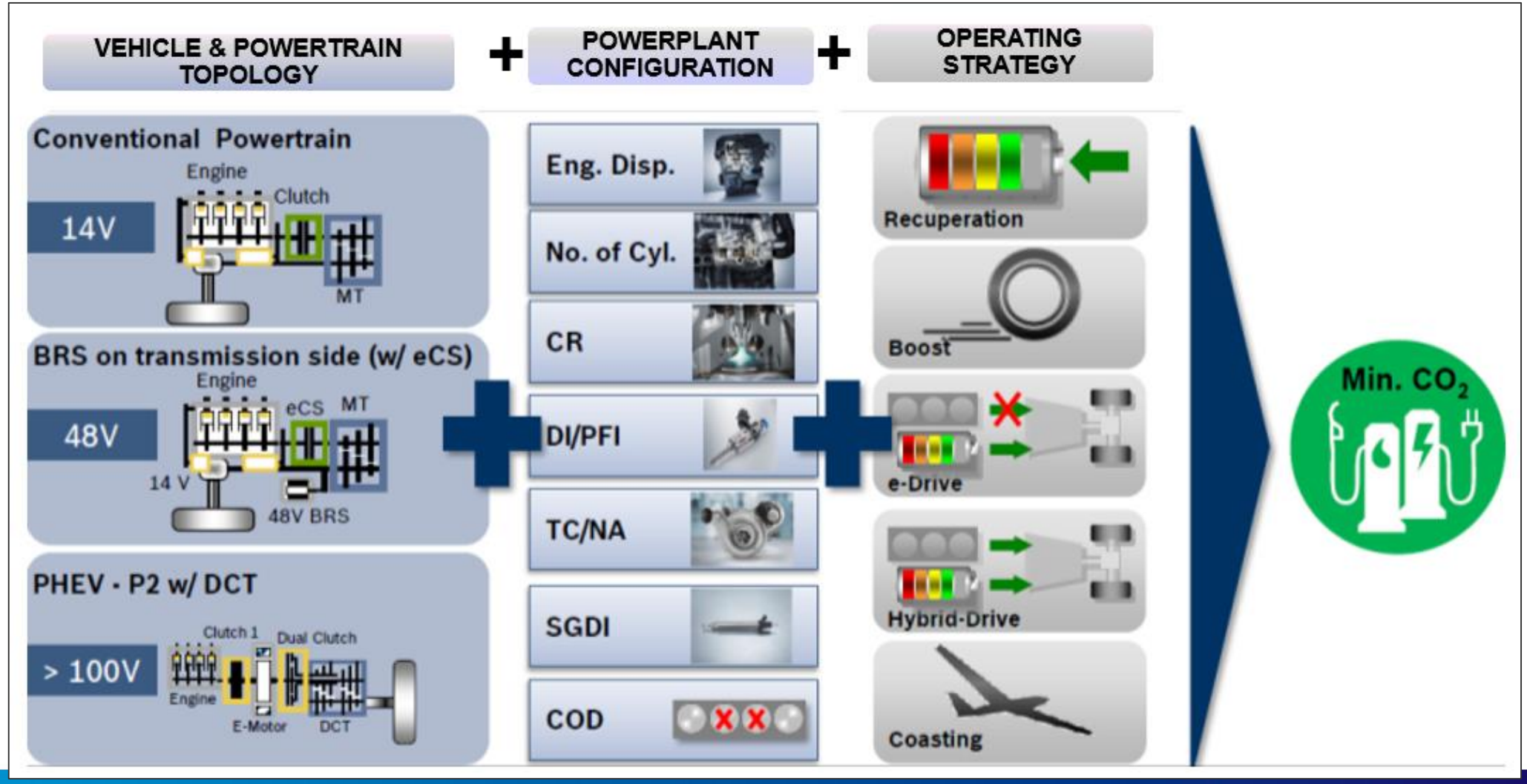
Low level Control Problem ➔ air/fuel ration of the SI engine, current control of the electric motor,Inverter etc.)

简介:处理复杂技术和新技术

- GT-SUITE是虚拟评估先进车辆系统的理想平台

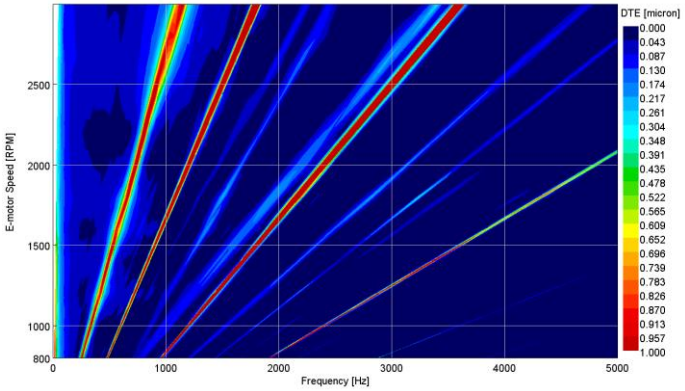
BOSCH

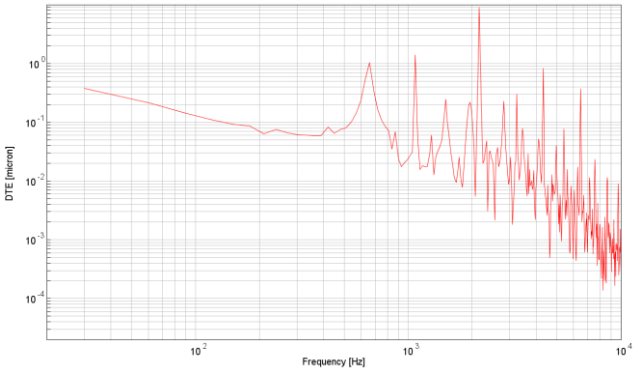
Example from:
Robert Bosch
GT Conference



简介: GT-SUITE如何在这个过程中提供帮助?

- 确定瞬态机动时的共振源
  - Tip-in, shift, change of mind, lugging…
- 识别系统的交互
  - 了解控制的影响
  - 优化校准
- 修改的:
  - 系统级
  - 部件级（齿轮几何，轴承，轴）



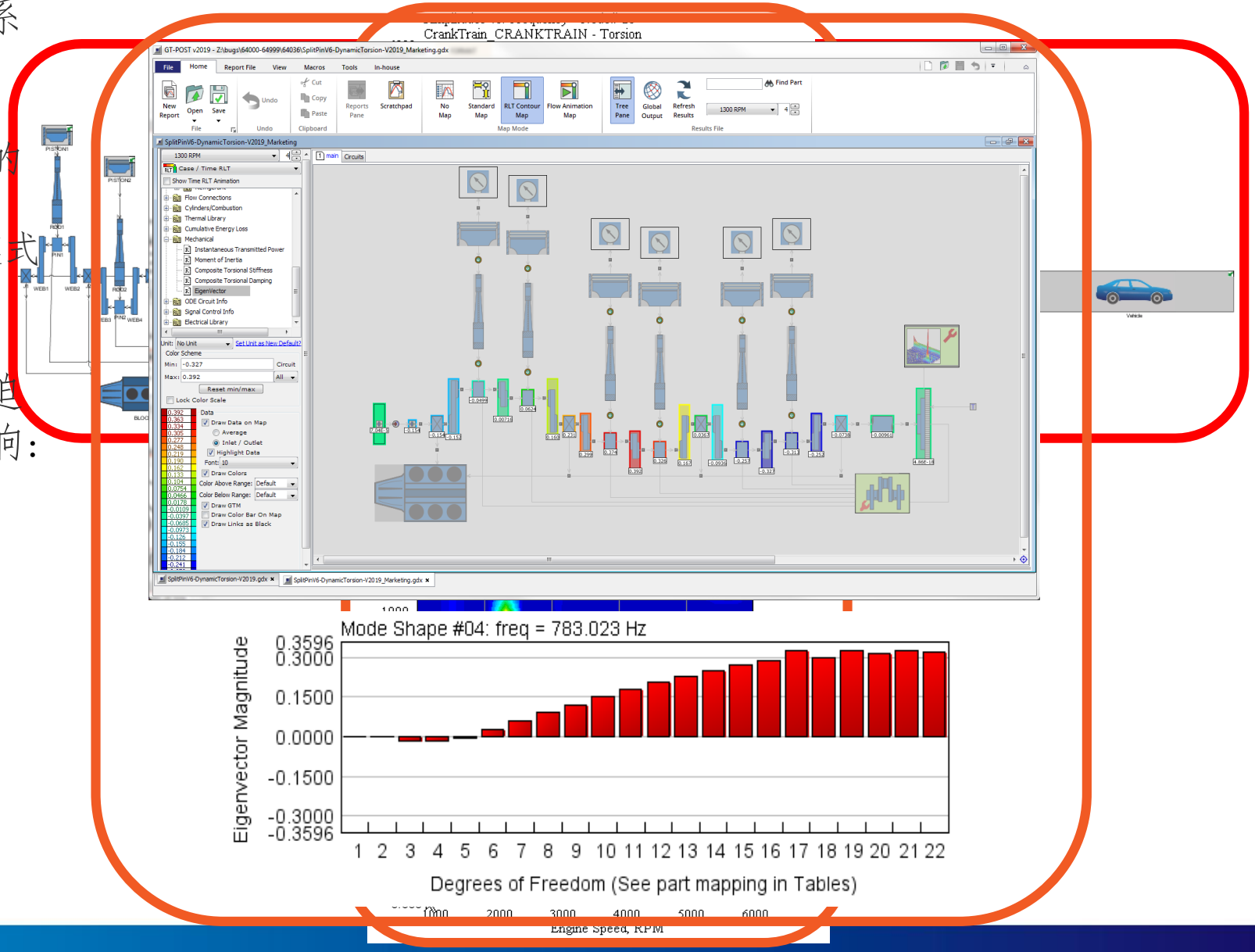


目录

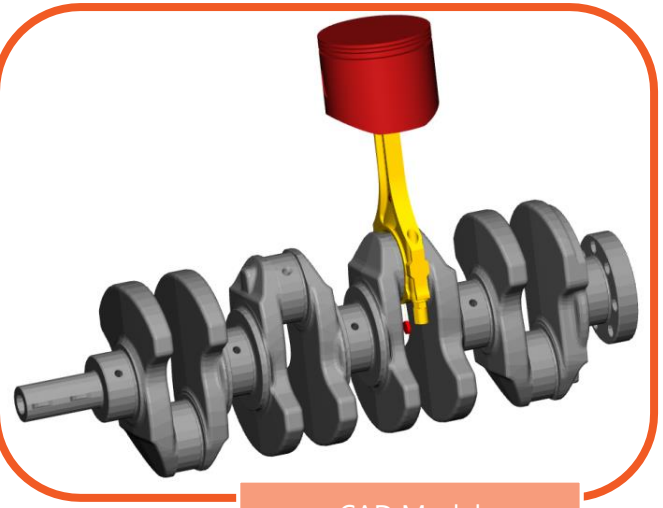
发动机振动分析: 频域分析

- 通过自定义模态分析快速表征传动系扭转模式，包括：
  - 频率相关的刚度和阻尼效应
  - 分支系统（e.g. 带动力传动系统的发动机）
  - 在一个用户友好的方式输出本征模式和频率

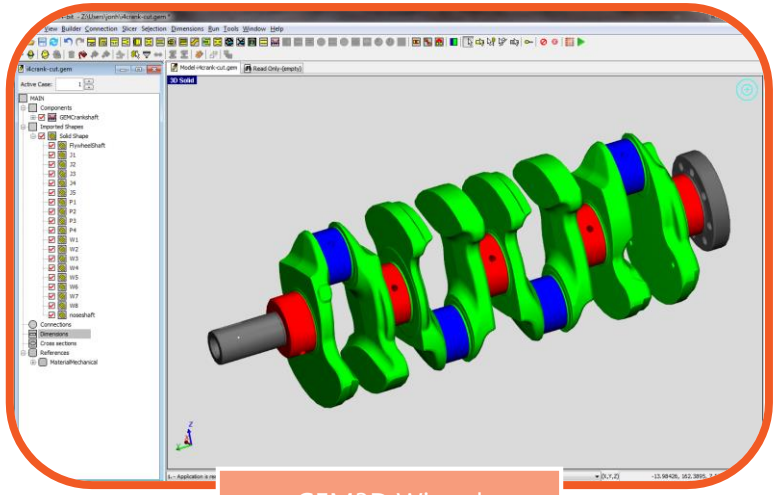
- 通过使用速度扫描来进行自定义受迫振动的频率分析来评估强制功能影响：
  - 自动检测/包含共振速度
  - 受迫函数的谐波含量



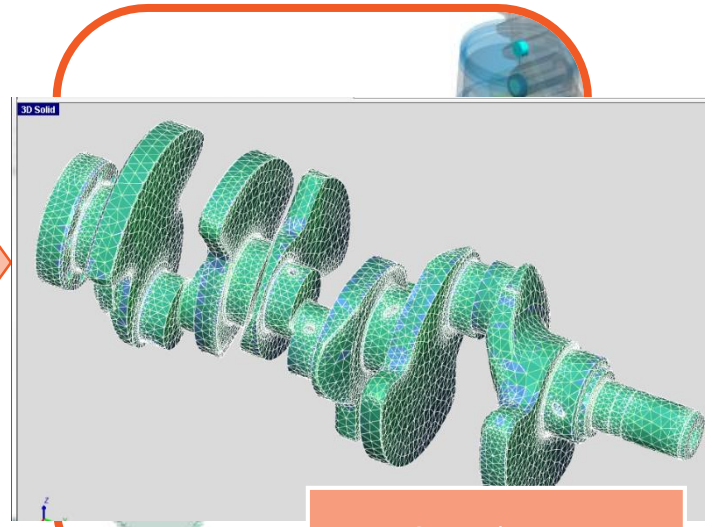
发动机振动分析：发动机不平衡和偏置分析



CAD Model



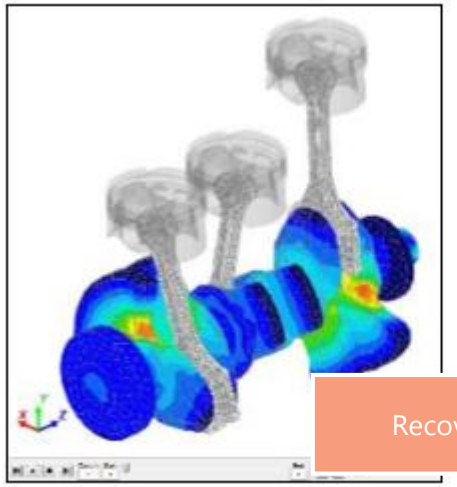
GEM3D Wizard



SuperElement

GT-SUITE

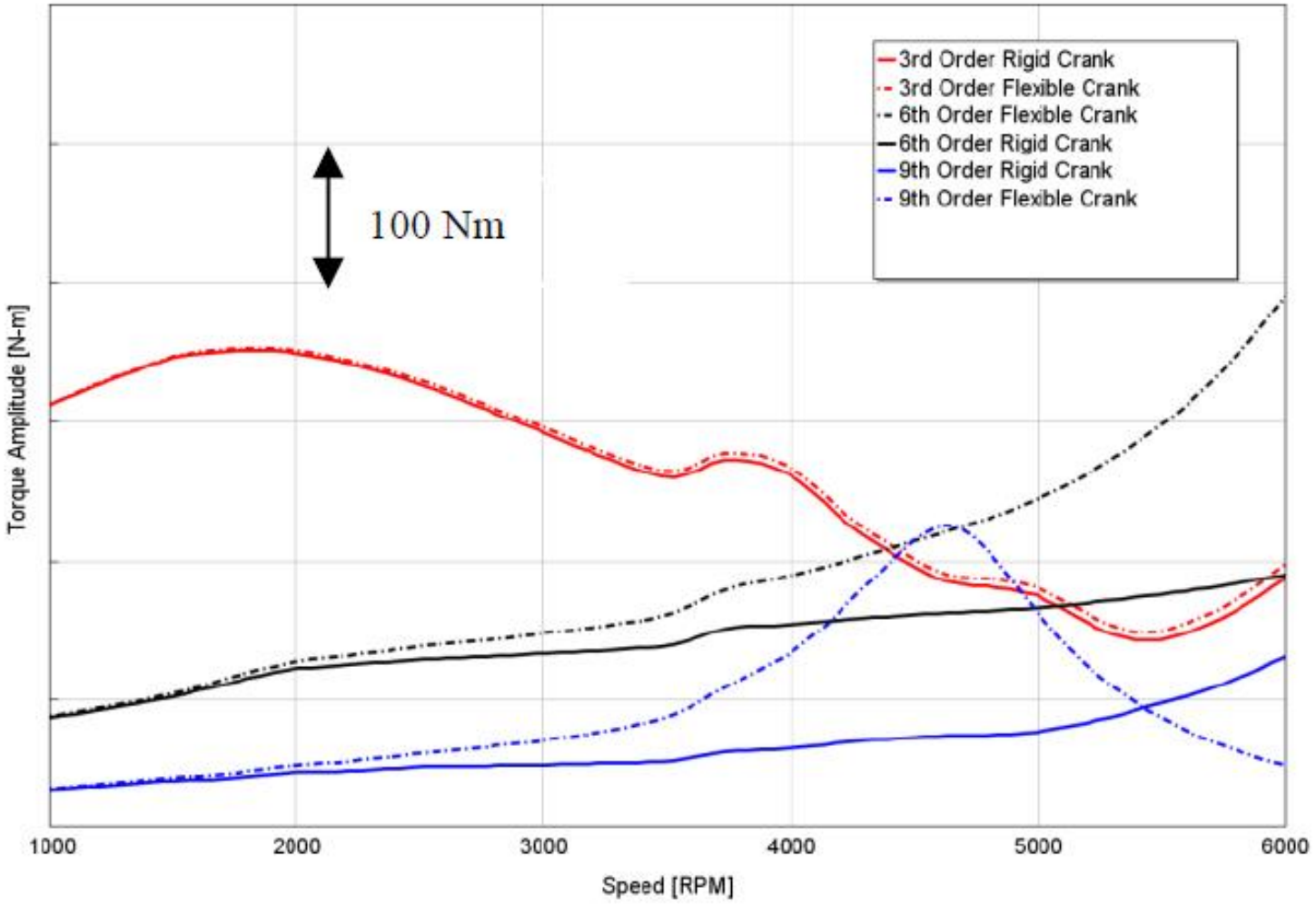
- 能够预测动态发动机偏转和不平衡问题：
  - 专业的GEM3D向导来导入几何图形
  - 3-D梁有限元（Timoschenko Elements）方式或 3D FE 超级单元
  - 定制等高线图来分析结果



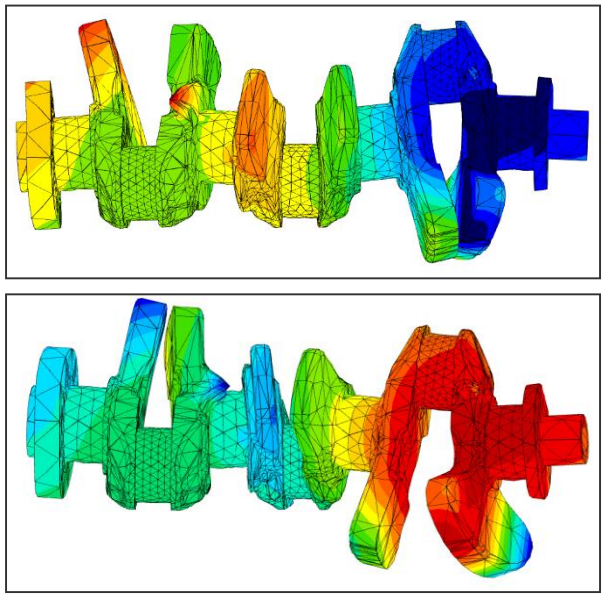
Recovered Strain Contour

发动机振动:发动机机灵活性的重要性

- 柔性体掩盖了更高的引擎阶次

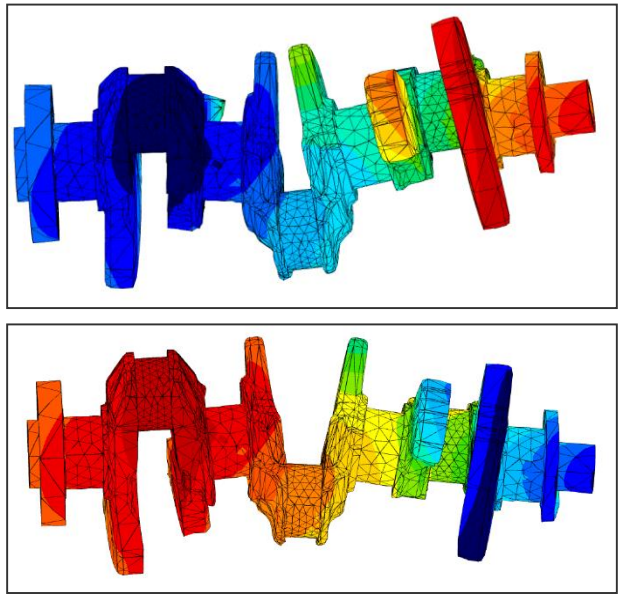


发动机振动分析: 曲轴模态分析

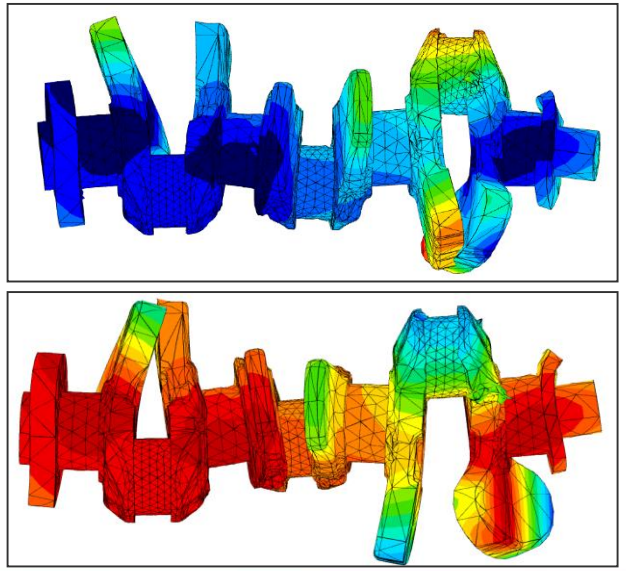


1st Mode

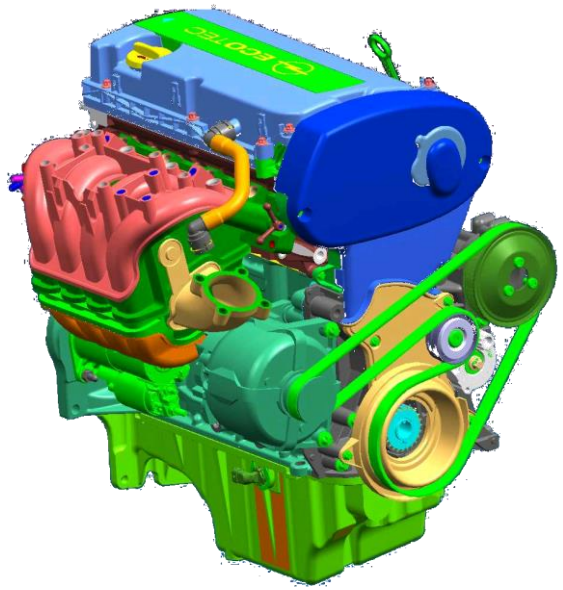
2nd Mode



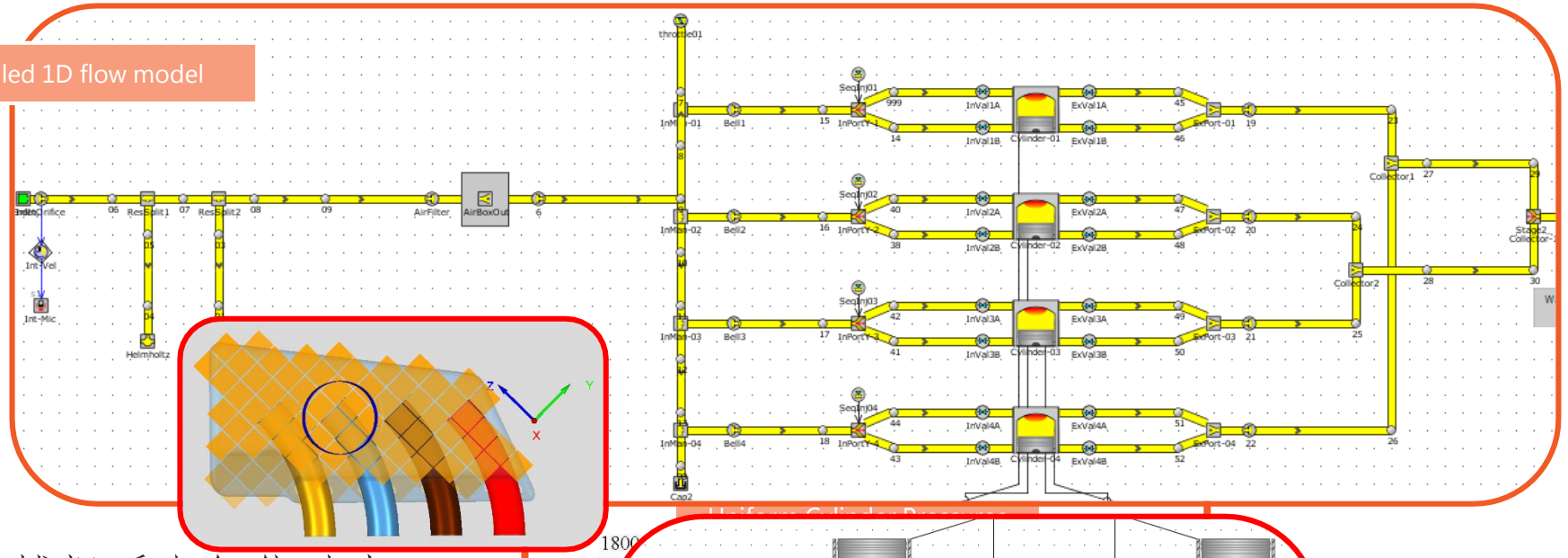
3rd Mode

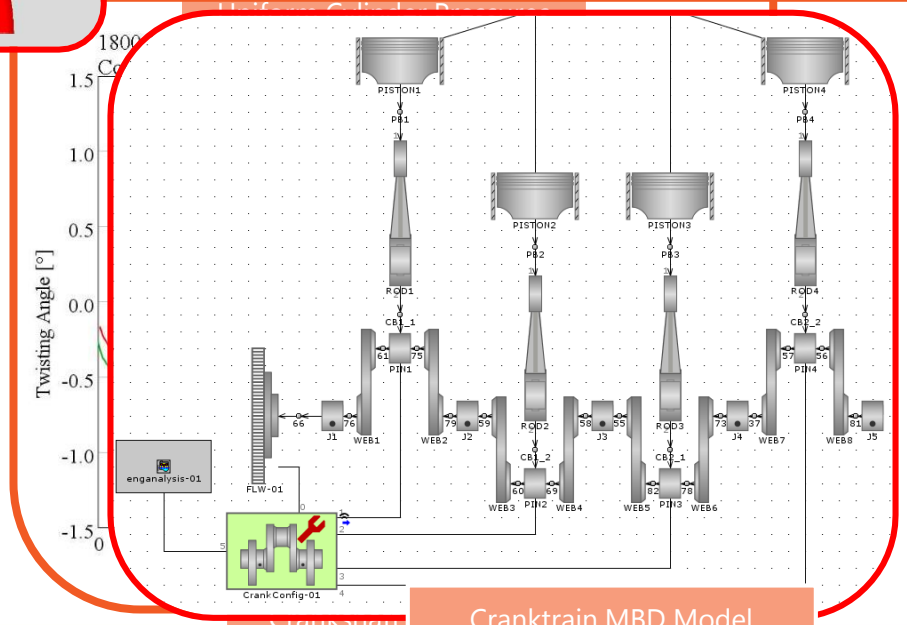


发动机振动分析:由气体动力学引起的发动机激励



Detailed 1D flow model

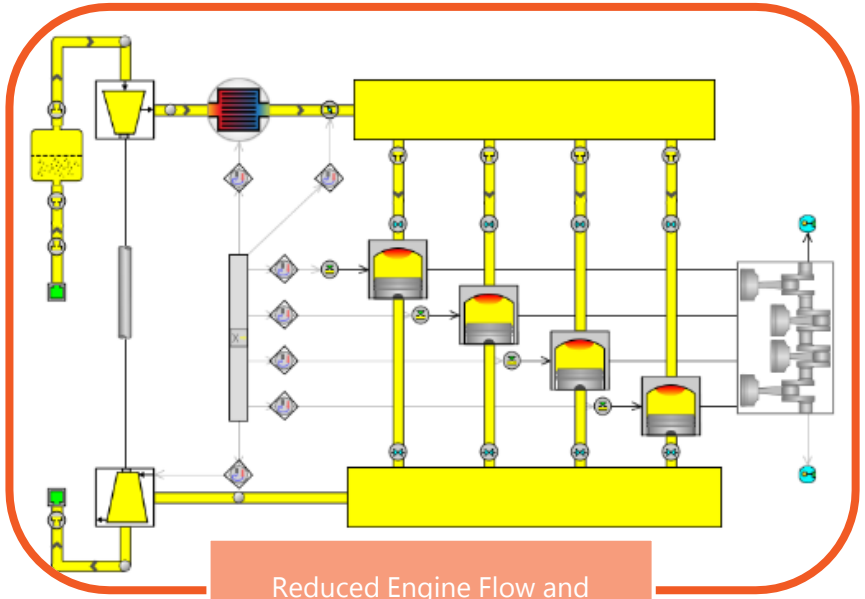




Cranktrain MBD Model

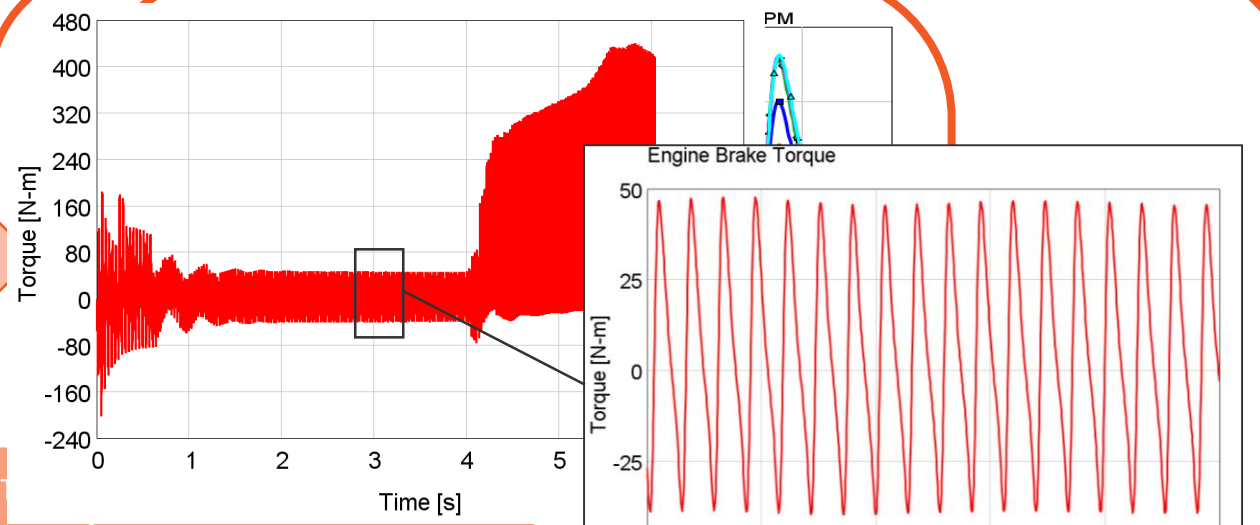
- 通过建立结构-流体耦合模型，捕捉瞬态气体动力学现象(失火、发动机起动、怠速)的影响:
  - 从进气到排气的一维热力学和流体动力学模拟，包括详细的燃烧过程
  - 解决由于曲轴动力学引起的汽缸压力的变化

发动机振动分析:快速运行发动机模型



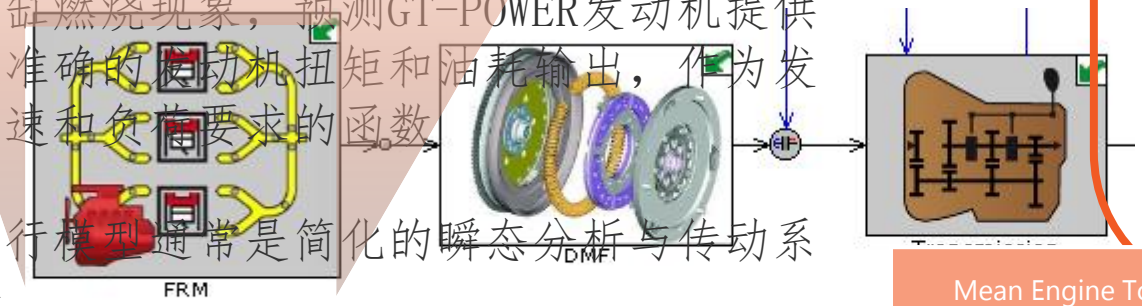
Reduced Engine Flow and Combustion Model

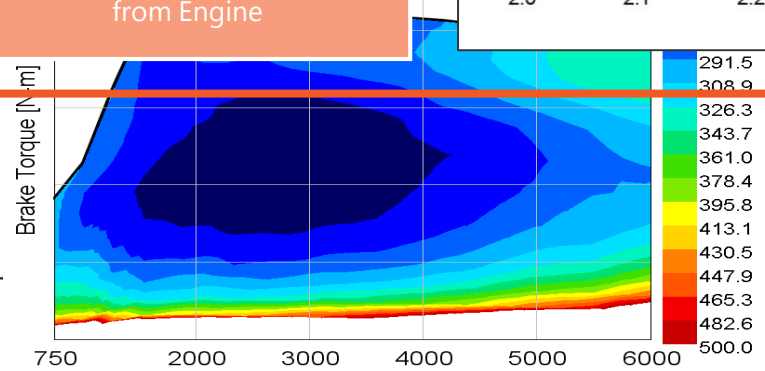
与传动系统的其余部分相结合，预测瞬态载荷



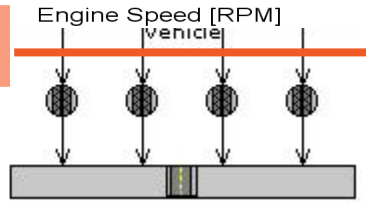
Resulting Transient Brake Torque from Engine

- 由于气缸燃烧现象，预测GT-POWER发动机提供物理上准确的发动机扭矩和油耗输出，作为发动机转速和负荷要求的函数
- 快速运行模型通常是简化的瞬态分析与传动系统耦合

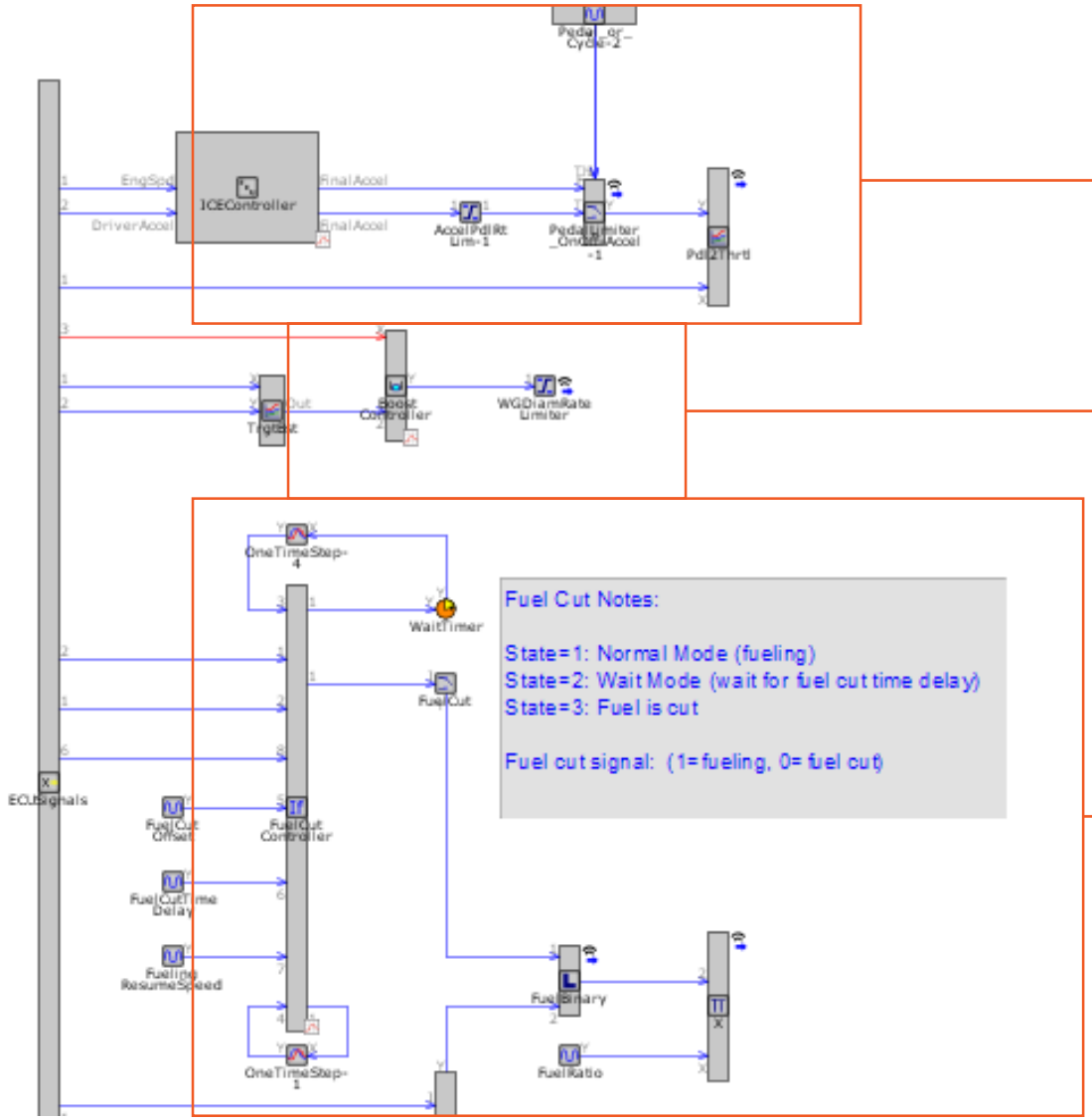




Mean Engine Torque Map



发动机振动分析：考虑ECU控制策略



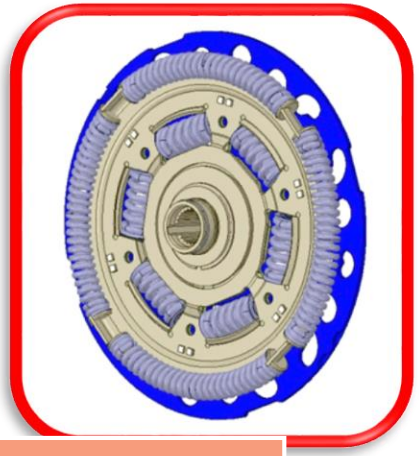
基于引擎速度和油门踏板使用PI控制来调整油门

使用PI控制器根据发动机转速、油门踏板和压缩机压力来调整增压

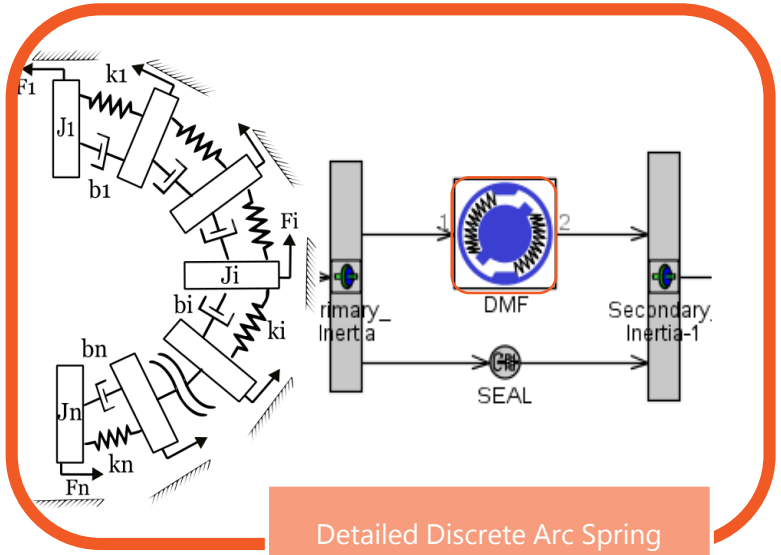
使用二进制逻辑确定是否进行燃料切断

传动系统振动分析：扭振阻尼器

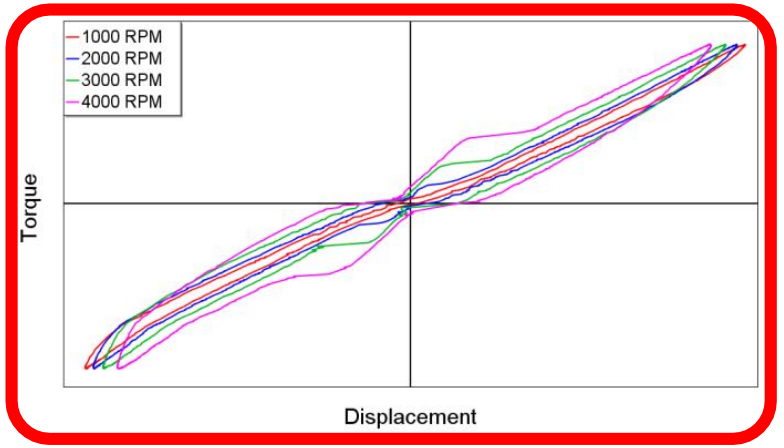
- 扭转阻尼器建模



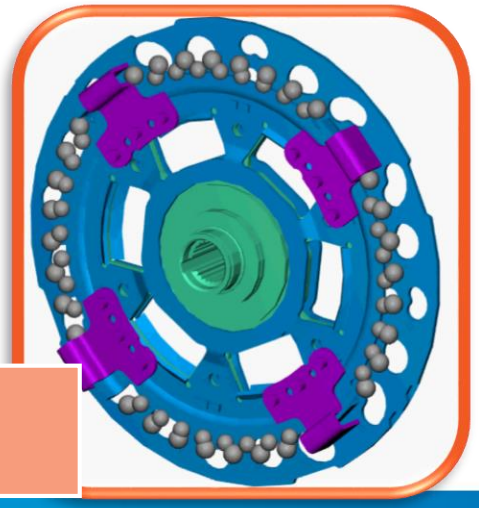
Extract Spring Data From Supplier



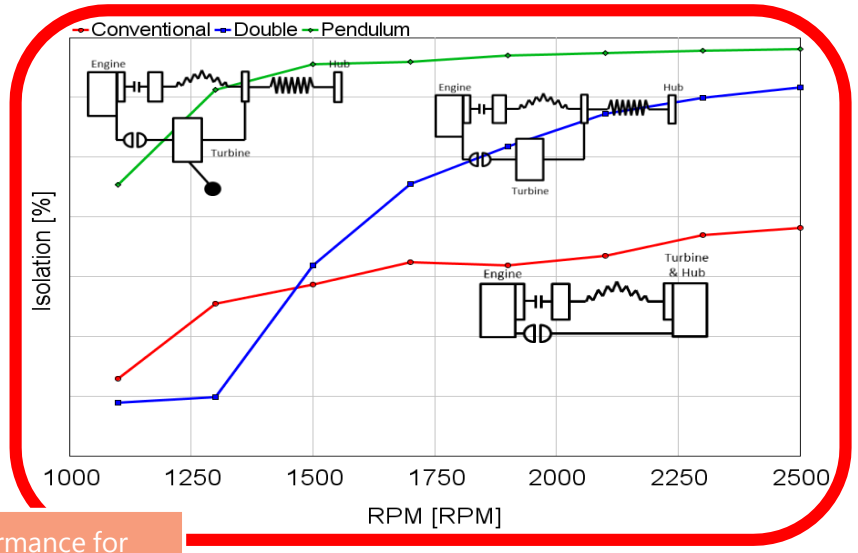
Detailed Discrete Arc Spring Model



Calibrate to hysteresis data



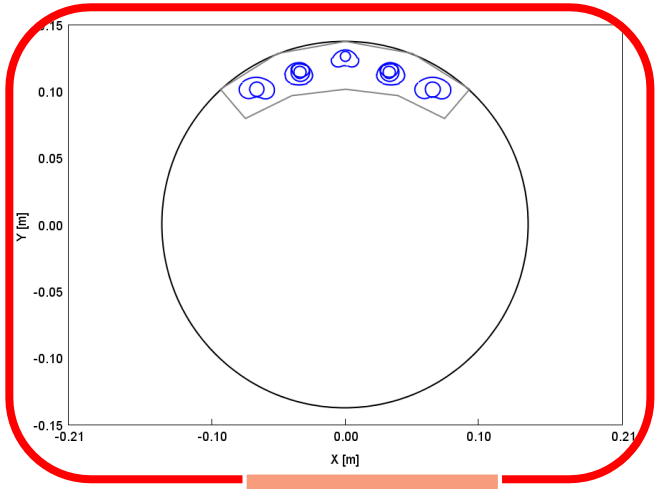
Visualize 3D motion



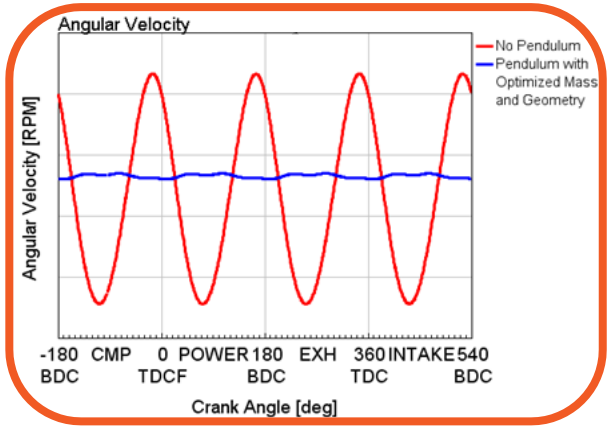
Analyze Isolation Performance for different arquitectures

传动系统振动分析: Pendulum Systems

Physical Hardware

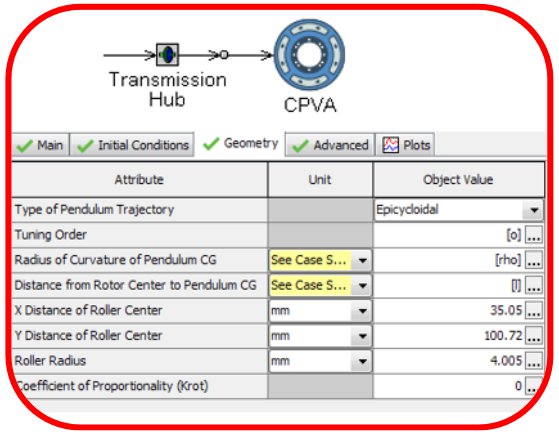


Detailed Contact Geometry



Check on Isolation Performance

- 复杂的、非线性的、具有平面运动的摆振吸收器，以隔离振荡的阶数
- 用户定义的接触几何辊和钟摆质量
- 传动系统综合模型的简化解



Extract geometric characteristics, trajectory and build pendulum model in GT-SUITE

3D Animation

GEM3D v2019 - ENJOY THE MERGE WITH RESPONSABILITY!!! GEM58 *

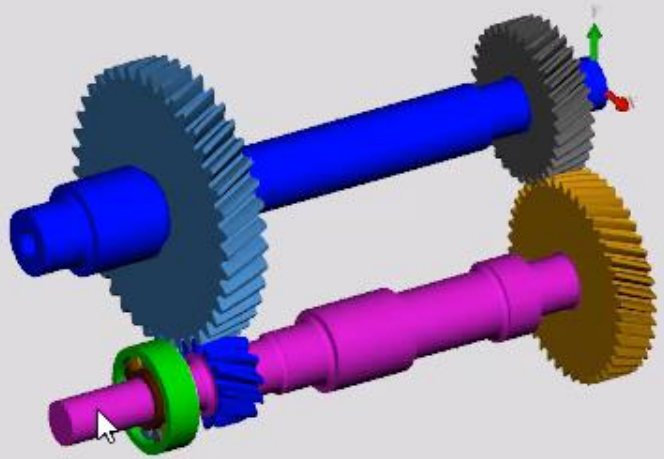
File | Home | View | Flow | Thermal | Mechanical | Convert | Dimension | Tools | INHOUSE | Component

New | Open | Save | Import 3D | Reload | Export ACIS | Export STL | Export Image — File
Undo | Redo | Stop — Undo
Advanced Copy + Paste | Cut | Copy | Paste — Clipboard
Template Library | Find Template | Find Value — Templates and Search
Selection | Box Selection | Drill Mode | Unselect All — Selection Mode
Case Setup | Export GT Model — Model Export

Active Case: 1

- Components
- Imported Shapes
  - Solid Shape
    - Input-Shaft-Right-Bearing-Solid1
    - Input-Shaft-Right-Bearing-Solid2
    - Input-Shaft-Right-Bearing-Solid3
    - Input-Shaft-Right-Bearing-Solid4
    - Input-Shaft-Right-Bearing-Solid5
    - Input-Shaft-Right-Bearing-Solid6
    - Input-Shaft-Right-Bearing-Solid7
    - Input-Shaft-Right-Bearing-Solid8
    - Input-Shaft-Right-Bearing-Solid9
    - Input-Shaft-Right-Bearing-Solid10
    - Input-Shaft-Right-Bearing-Solid11
    - Input-Shaft-Right-Bearing-Solid12
    - Input-Shaft-Right-Bearing-Solid13
    - Input-Shaft-Solid
    - Lay-Shaft-Solid
    - Pinion-1-Solid1
    - Pinion-5-Solid1
    - Wheel-1-Solid1
    - Wheel-5-Solid1
- Connections
- Dimensions
- Cross sections
- References
  - MaterialMechanical
    - Steel

3D Solid



16. - Feature Snap Plane creation cancelled by the user.

(X,Y,Z) 10.8406, 1.956497, 152.2031 mm

Libraries | GEM58

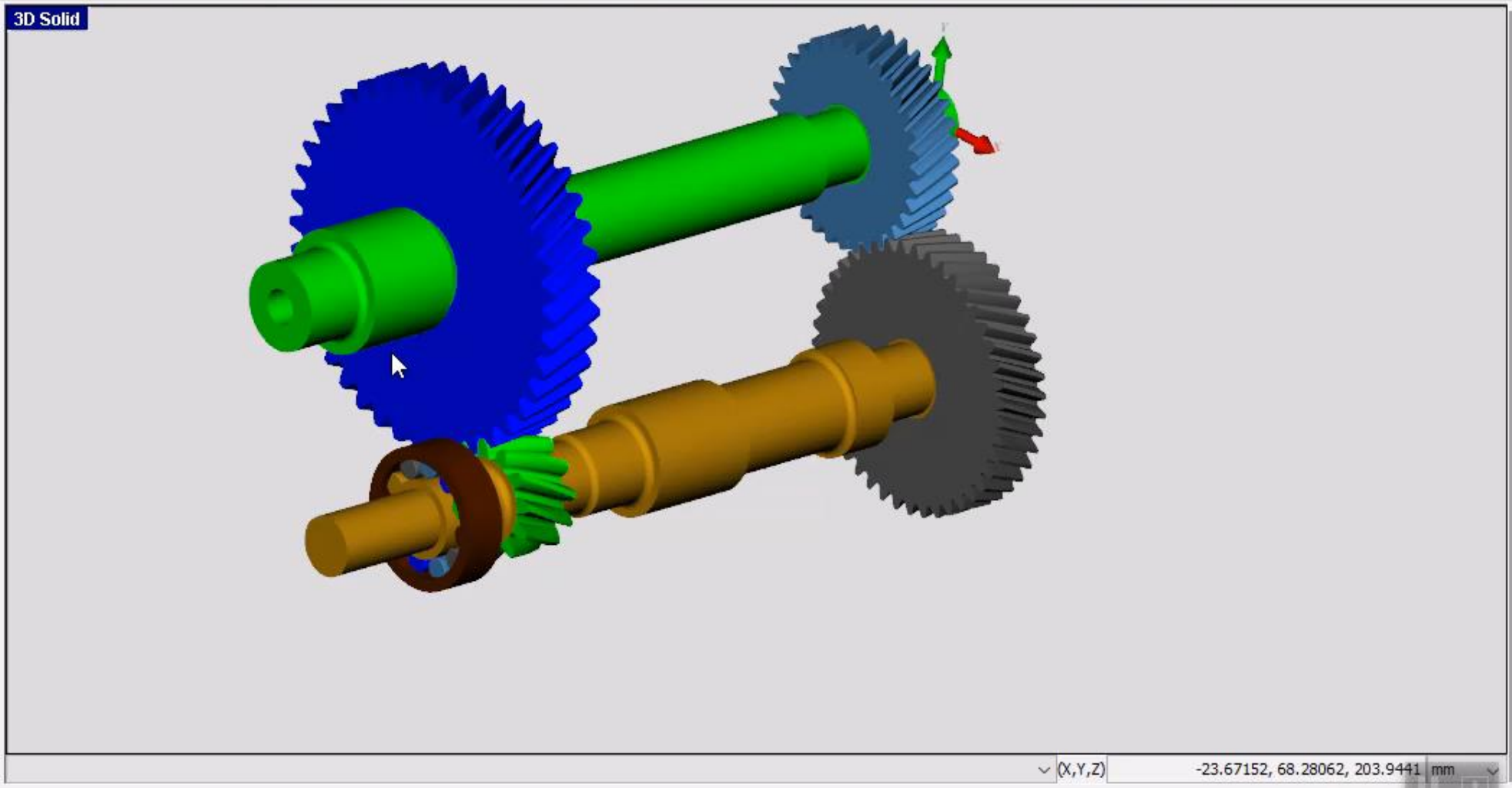
GEM3D v2019 - ENJOY THE MERGE WITH RESPONSABILITY!!! GEM2 *

File | Home | View | Flow | Thermal | Mechanical | Convert | Dimension | Tools | INHOUSE | Component

New | Open | Save | Import 3D | Reload | Export ACIS | Export STL | Export Image — File
Undo | Redo | Stop — Undo
Advanced Copy + Paste | Cut | Copy | Paste — Clipboard
Template Library | Find Template | Find Value — Templates and Search
Selection | Box Selection | Drill Mode | Unselect All — Selection Mode
Case Setup | Export GT Model — Model Export

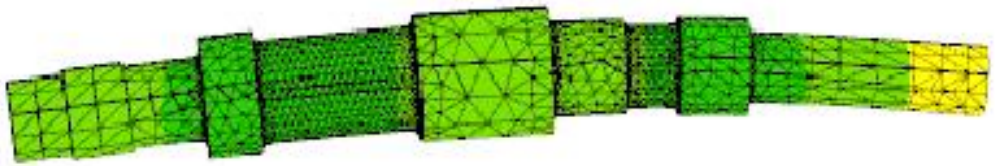
Active Case: 1

- MAIN
  - Components
    - GEMMechSolid3D
    - LocalOrigin
  - Imported Shapes
    - Solid Shape
      - Input-Shaft-Right-Bearing-Solid1
      - Input-Shaft-Right-Bearing-Solid2
      - Input-Shaft-Right-Bearing-Solid3
      - Input-Shaft-Right-Bearing-Solid4
      - Input-Shaft-Right-Bearing-Solid5
      - Input-Shaft-Right-Bearing-Solid6
      - Input-Shaft-Right-Bearing-Solid7
      - Input-Shaft-Right-Bearing-Solid8
      - Input-Shaft-Right-Bearing-Solid9
      - Input-Shaft-Right-Bearing-Solid10
      - Input-Shaft-Right-Bearing-Solid11
      - Input-Shaft-Right-Bearing-Solid12
      - Input-Shaft-Right-Bearing-Solid13
      - Input-Shaft-Solid
      - Lay-Shaft-Solid
      - Pinion-1-Solid1
      - Pinion-5-Solid1
      - Wheel-1-Solid1
      - Wheel-5-Solid1
  - Connections
  - Dimensions
  - Cross sections

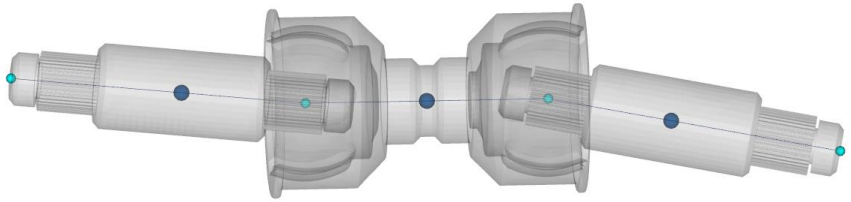


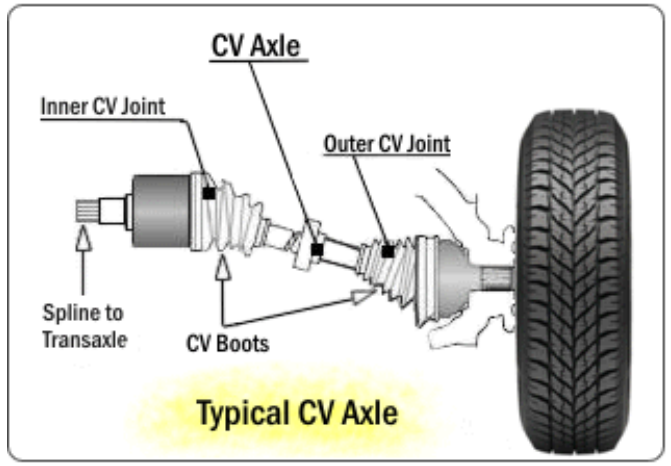
Libraries | GEM2

传动系统振动分析：第一和第二轴模态



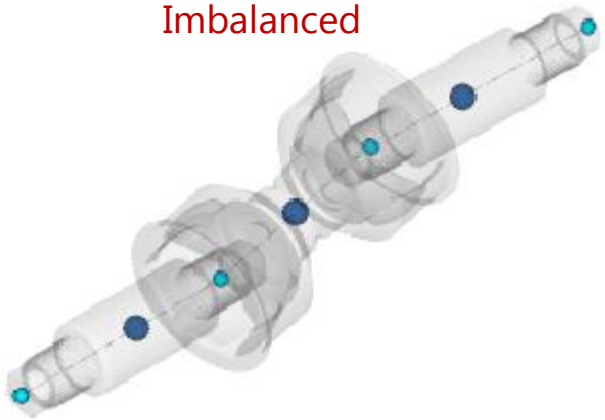
传动系统振动分析: 万向节不平衡分析





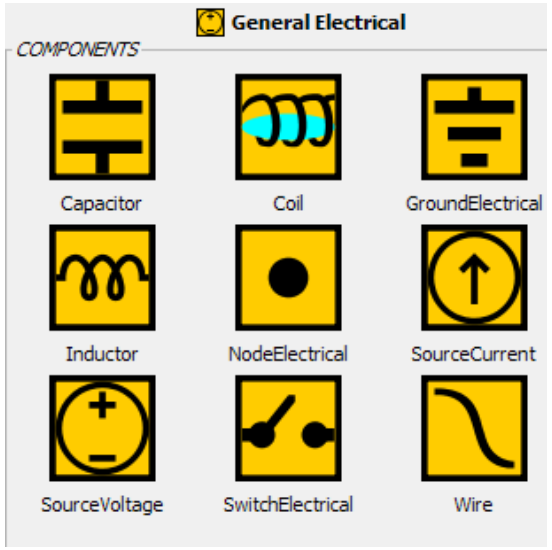
Balanced

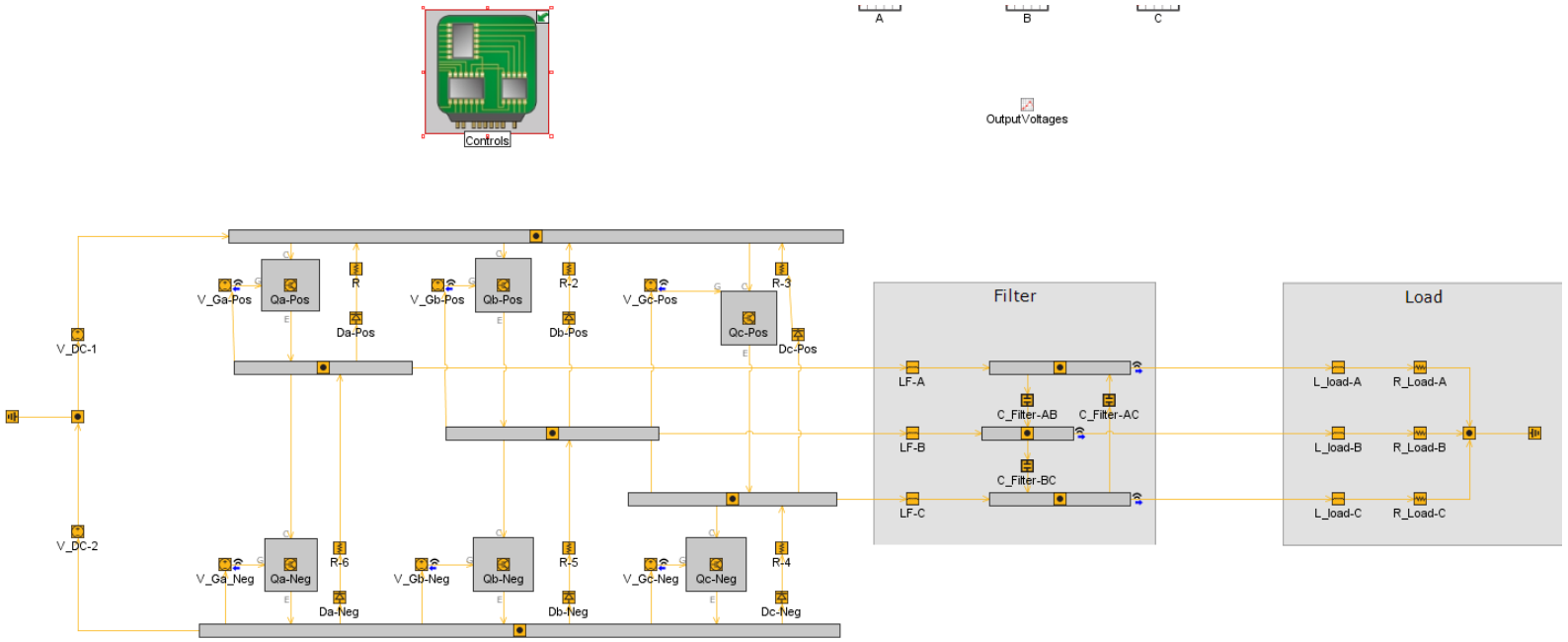
Imbalanced



电机振动: 逆变器开关频率

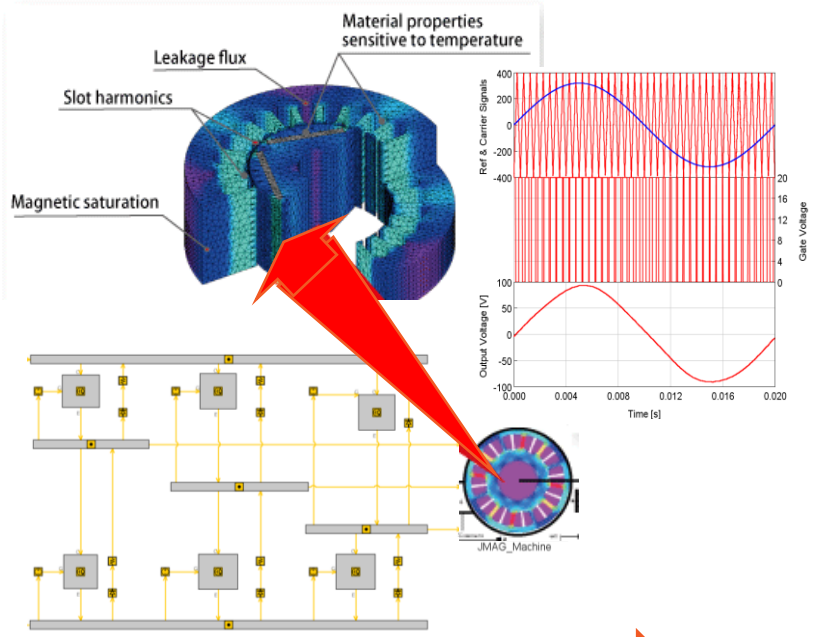
- 逆变器脉宽调制器(PWM) DC-AC
- 逆变器控制策略影响
  - DQ-Controller设置PWM控制的电流目标
- 示例可以在GT-SUITE电气库中获得



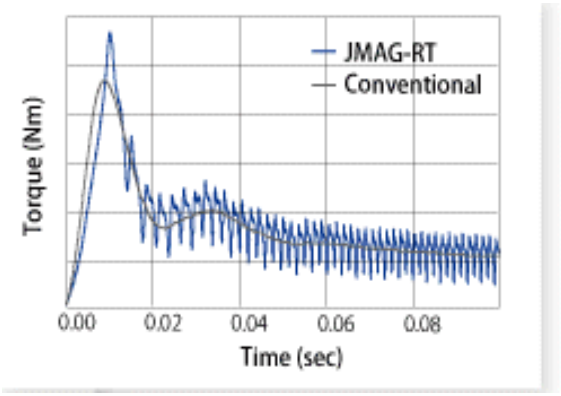


电机振动：与JMAG RT联合仿真

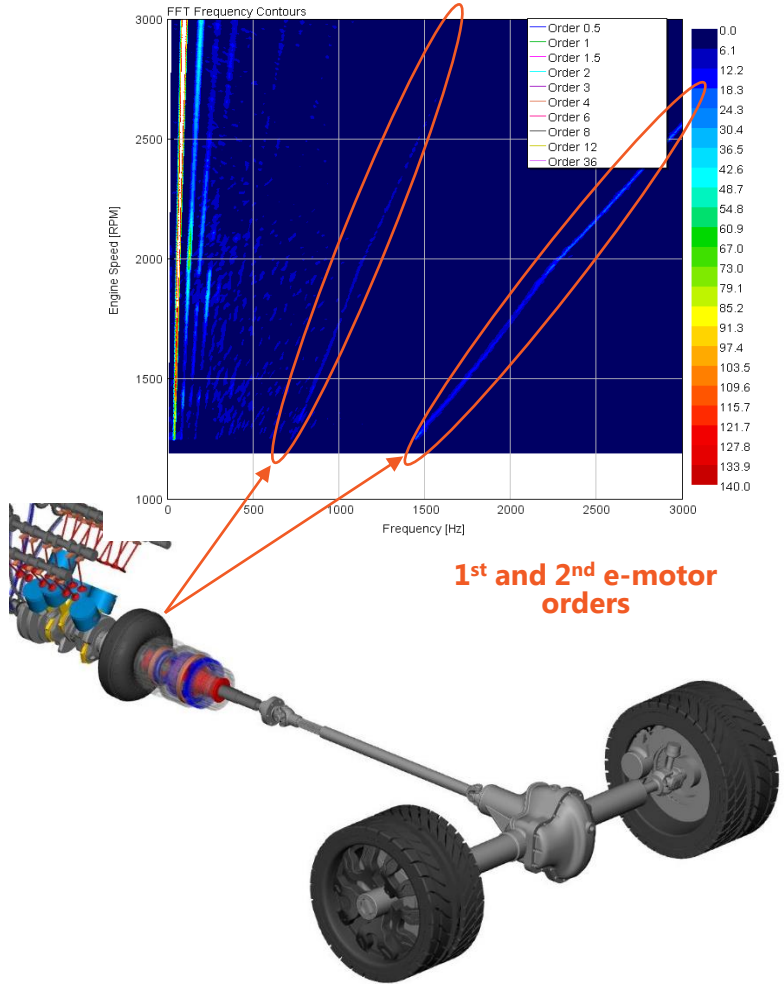
- 与JMAG .RTT文件进行联合仿真
- 可以捕获更高阶的扭矩波动，由于：
  - 逆变器开关频率
  - 定子槽和极



D-Q Control 3-phase currents



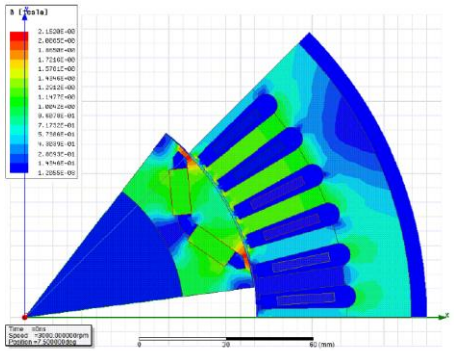
Predict E-motor transient torque

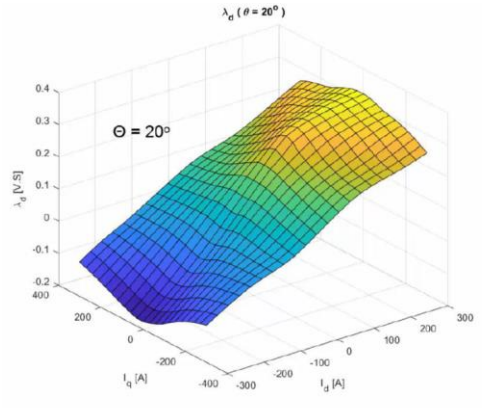


Analyze Integrated MBD Driveline Response

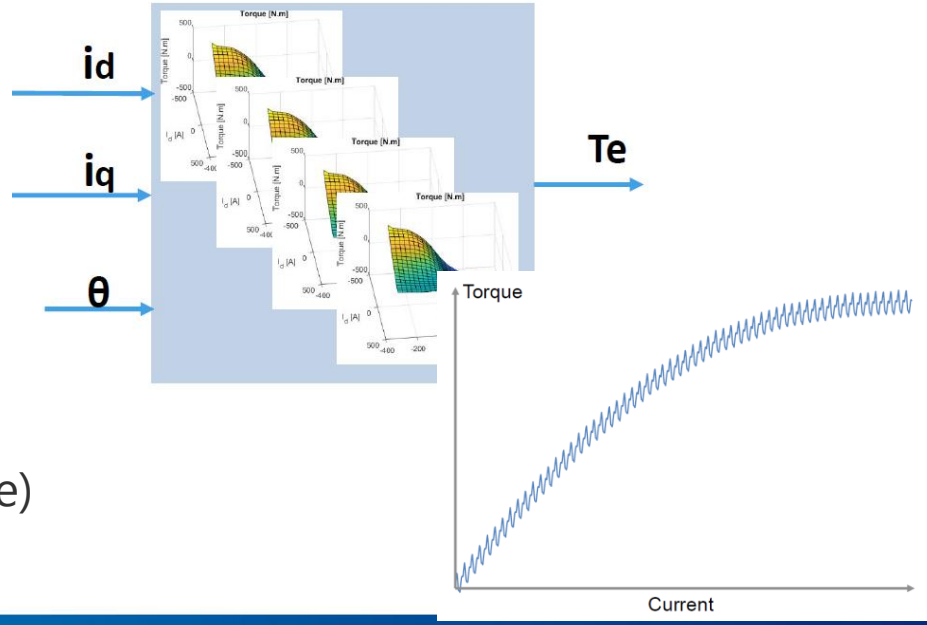
电机振动：与JMAG RT联合仿真

- 将电当量模型与通量图结合(需要大量的模型校准)
- 捕捉:高频动力学，如磁场与定子槽(齿槽)的相互作用。适用于传动系统NVH





Flux maps (function of rotor angle)



Lower Model Fidelity
Faster Simulation

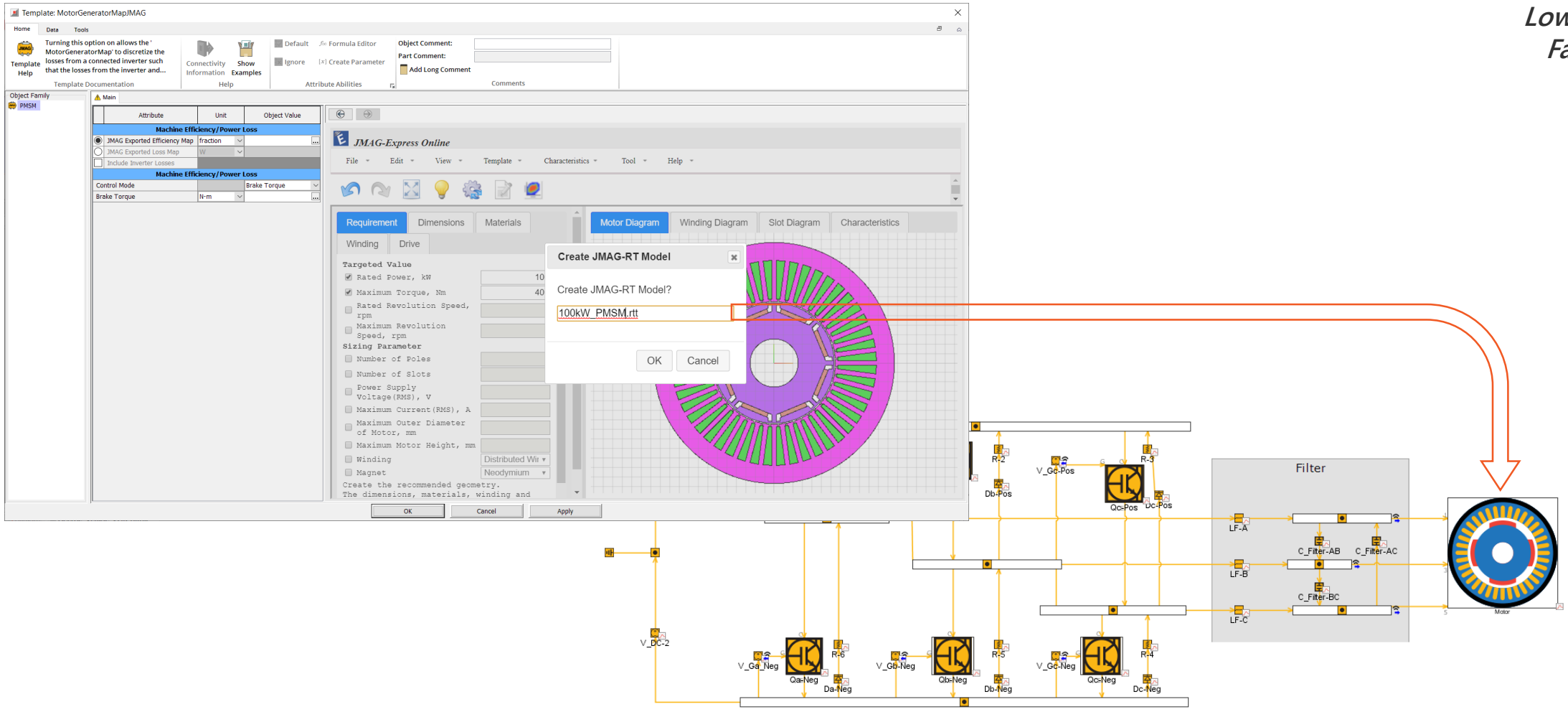
Dynamic Electrical-Equivalent

Dynamic Electrical-Equivalent + Spatial Harmonics

E-Mag FEA

Higher Model Fidelity
Slower Simulation

电机振动：与JMAG RT联合仿真



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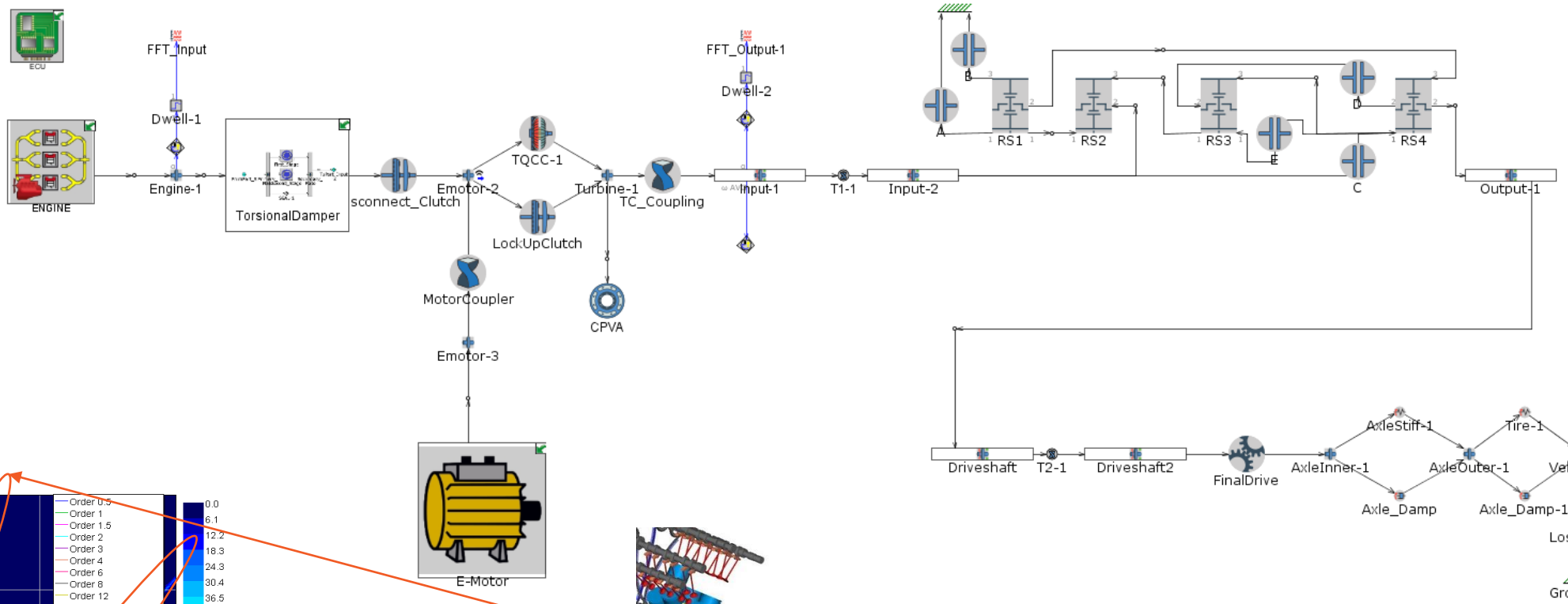
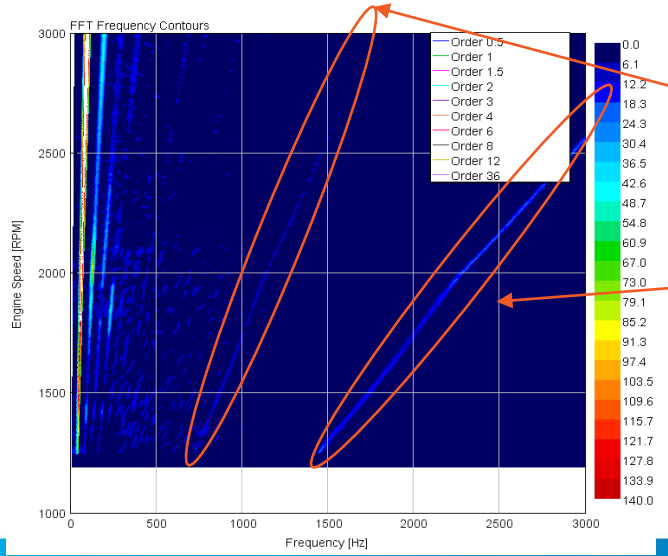
Slower Simulation

JMAG-RT Model Import into GT-SUITE

电机振动 用于传动系统NVH分析的详细的电机模型

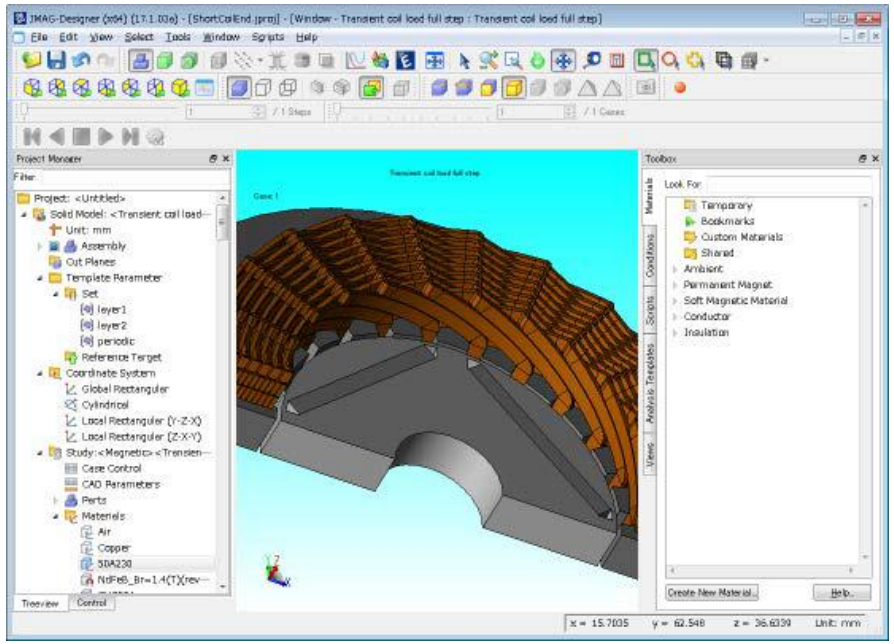




1st and 2nd e-motor orders

电机振动:电机建模及频谱

- 全电磁方案是详细设计和分析的预测方案
- 捕捉:空间分辨磁场和不平衡力，空间分辨损耗



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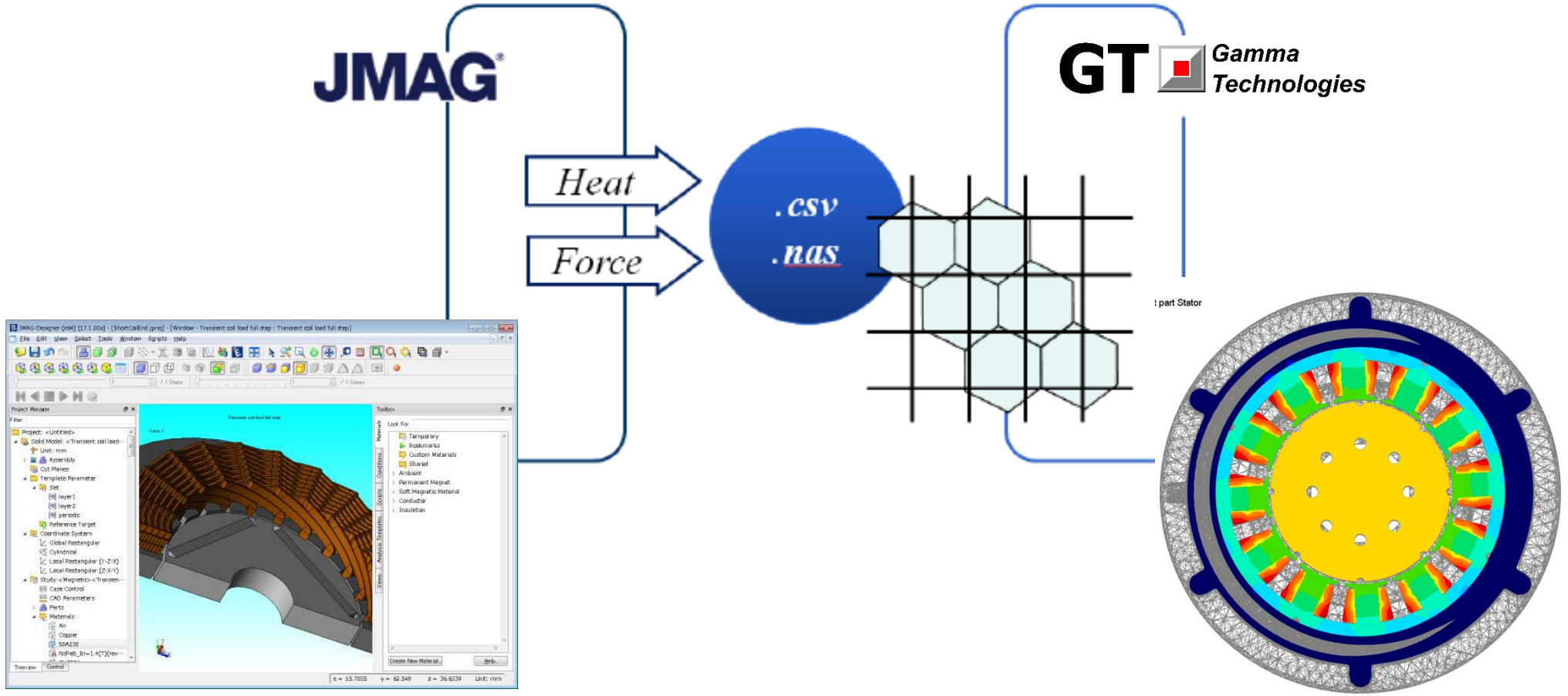
电机振动:电机建模及频谱



Lower Model Fidelity
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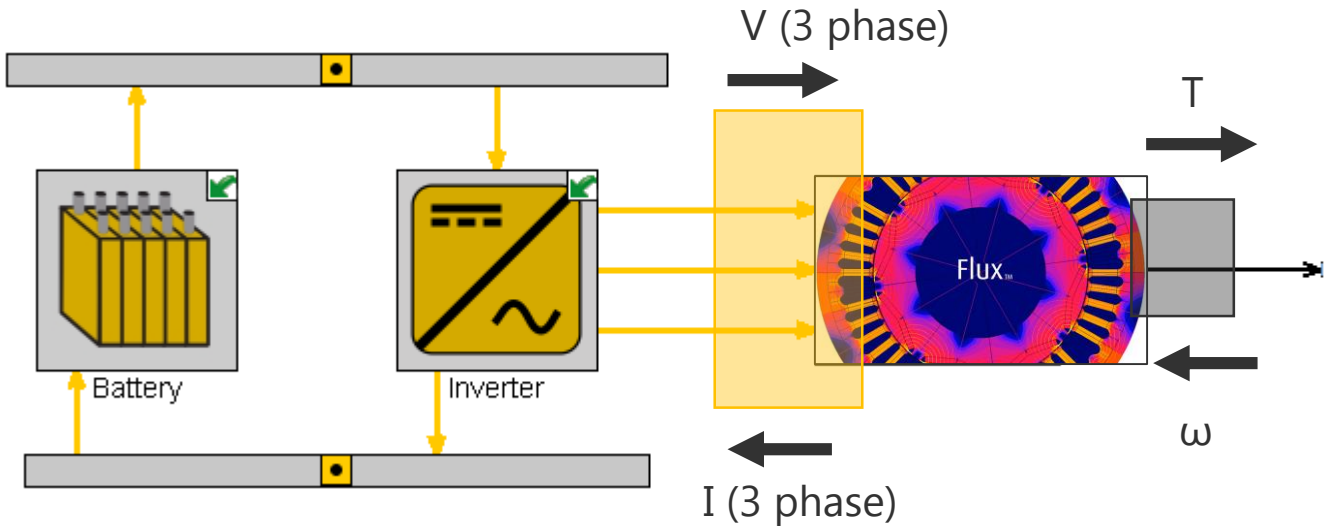
E-Mag FEA

Higher Model Fidelity
Slower Simulation

JMAG Designer Export of Boundary Conditions

- Co-simulation coupling with Altair Flux/Ansys Maxwell motor design tool



Lower Model Fidelity
Faster Simulation

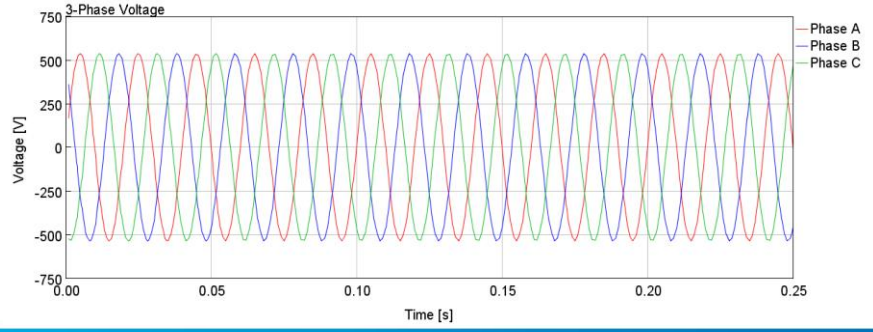
Dynamic Electrical-Equivalent

Dynamic Electrical-Equivalent + Spatial Harmonics

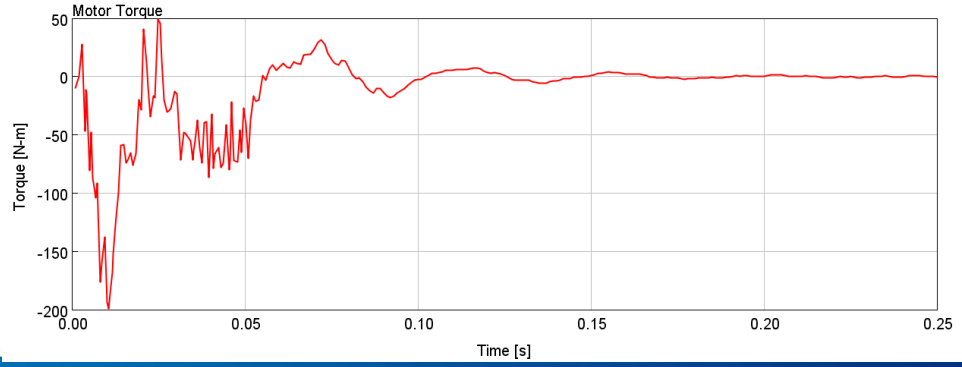
E-Mag FEA

Higher Model Fidelity
Slower Simulation

3-Phase Electrical Ports



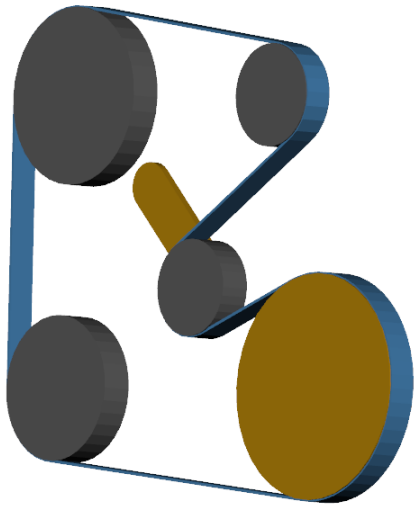
Mechanical Port



目录

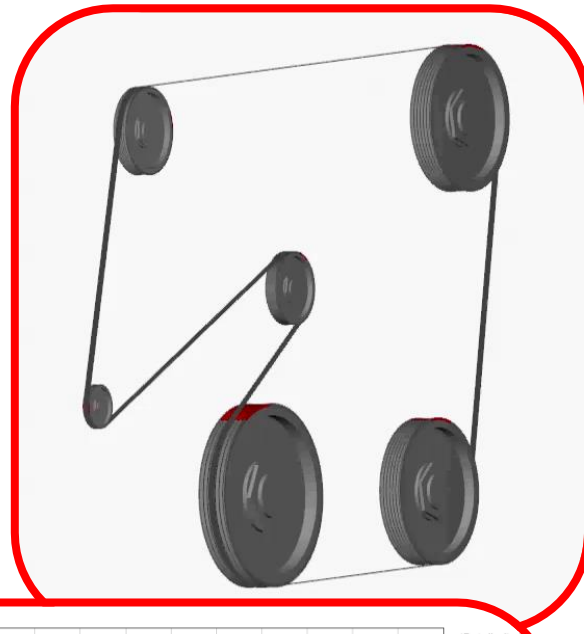
Start-Stop: 简介

- 非常常见的问题，特别是在48V的HEV中
- 归因于:
  - 曲轴的激励由于负载的冲击而产生的控制响应
- 关键物理现象模拟:
  - FE带模型预测BSG粘滑
  - 发动机刚体特性
- 相关的问题: Clunk, Shuffle



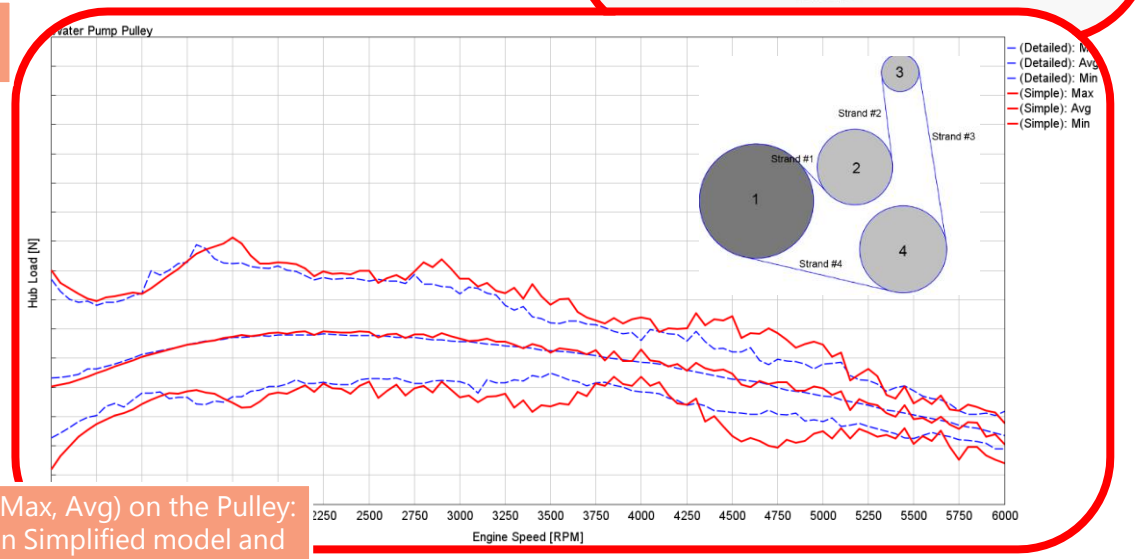
Start-Stop: Belt solution

- 研究FEAD和BSG带在不同频率下引起的发动机振动问题：
  - 带粘滑运动
  - 皮带摆动和错位
- 定制的解决方案包括：
  - 基于有限元的电缆或梁单元模型符合带弹性动力学第一原理
  - 连接滑轮和张力装置
  - 详细的动画输出
  - 可能添加一个“简化”的更快的解决方案
  - 集成发动机(GT-POWER)，详细的曲轴，气门系统和定时驱动或传动系统和车辆模型，以研究集成的NVH问题



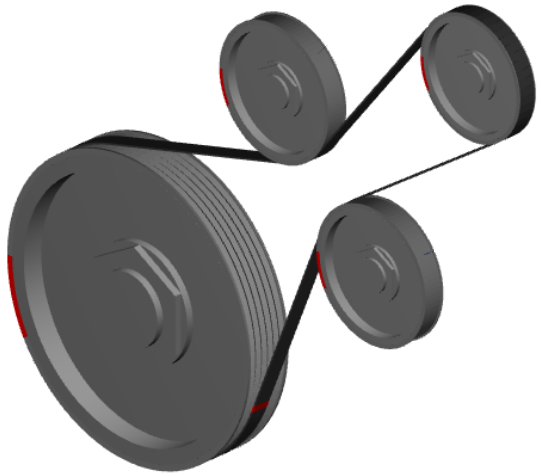
Belt Flapping

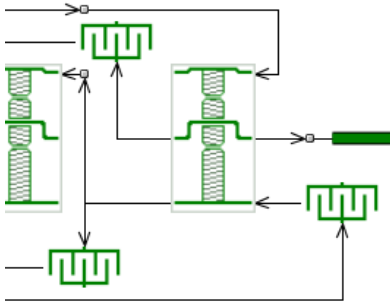
Axial Force Distribution for a tooth belt

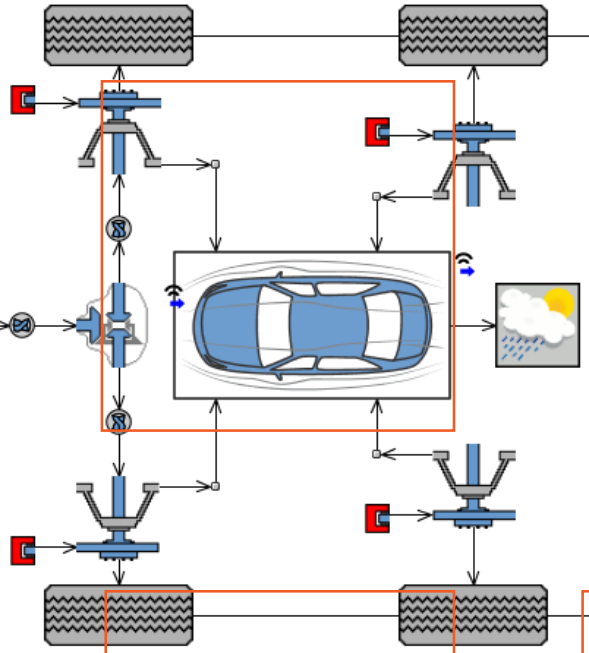


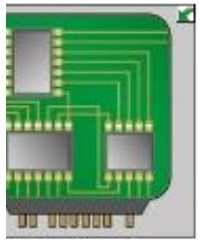
Load Reactions(Min, Max, Avg) on the Pulley: Comparison between Simplified model and beam element model

Start-Stop:用BSG系统从静止到起动



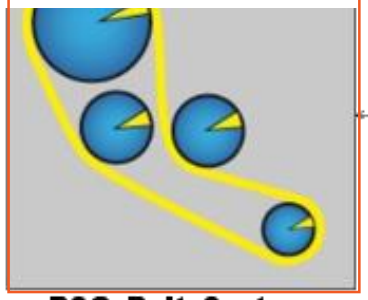




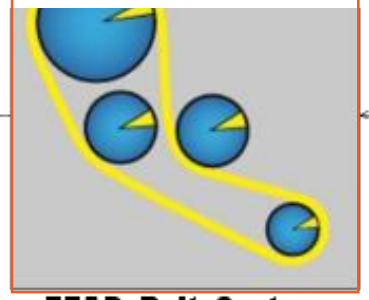


Controls

Driver



BSG_Belt_System

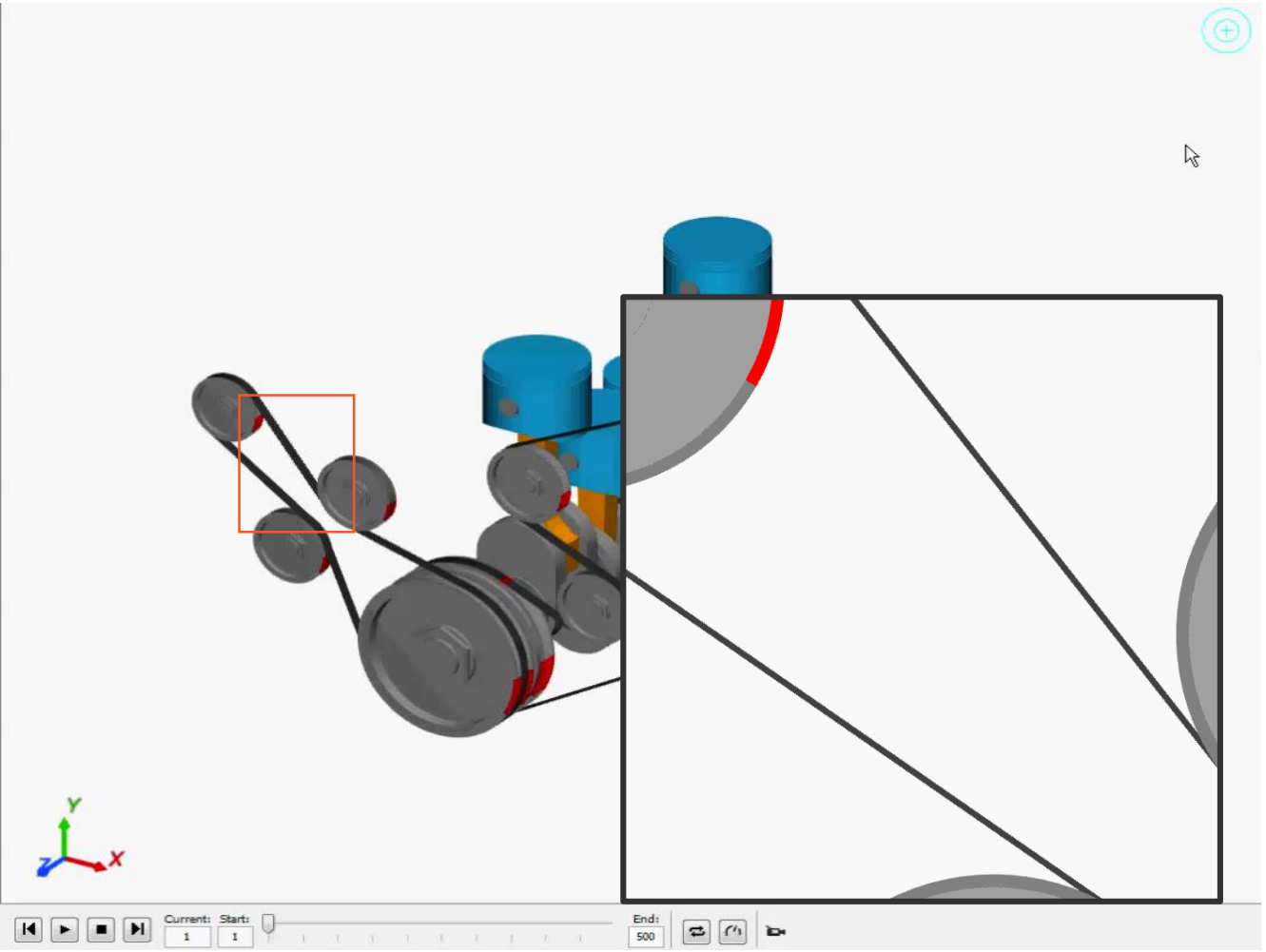


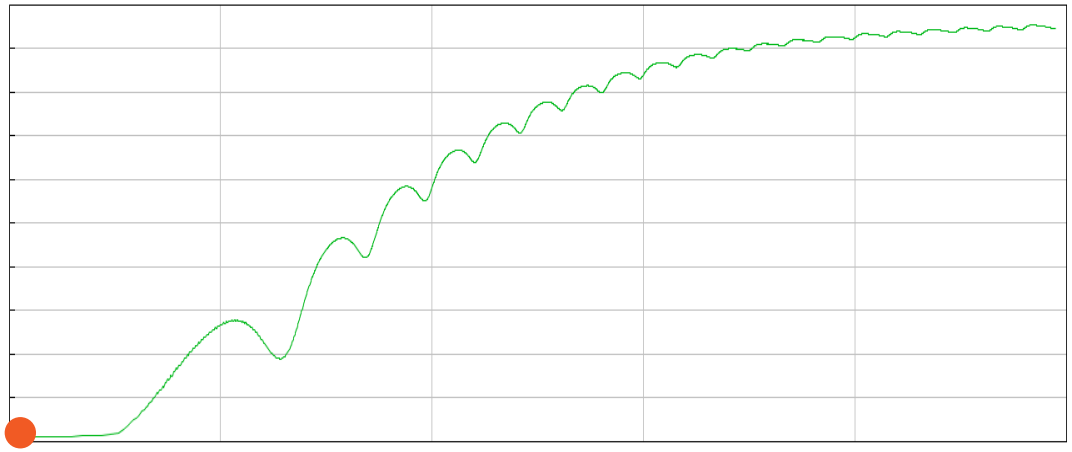
FEAD_Belt_System

Cranktrain

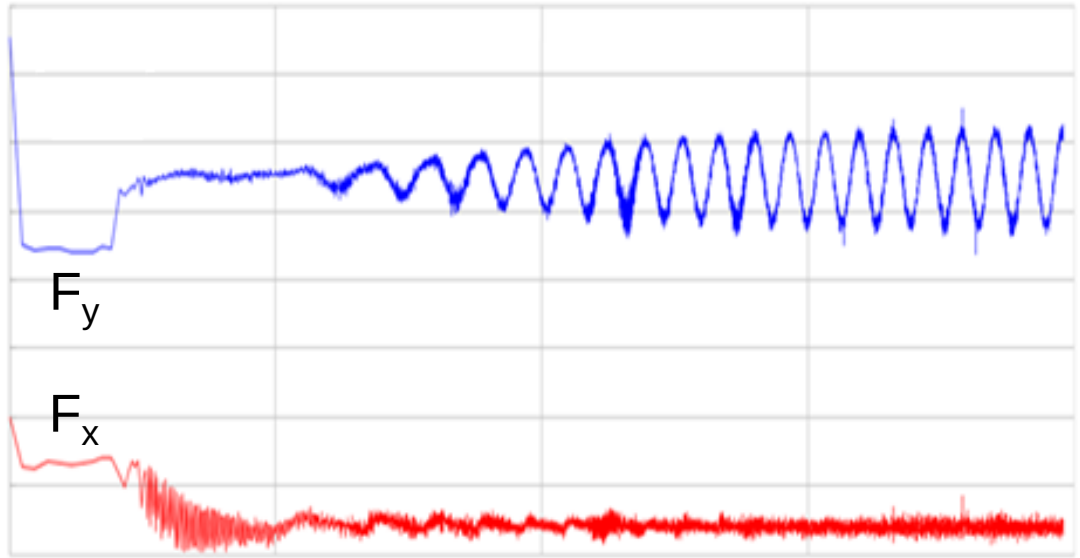
Vehicle_Driveline

Start-Stop:用BSG系统从静止到起动





Engine Speed

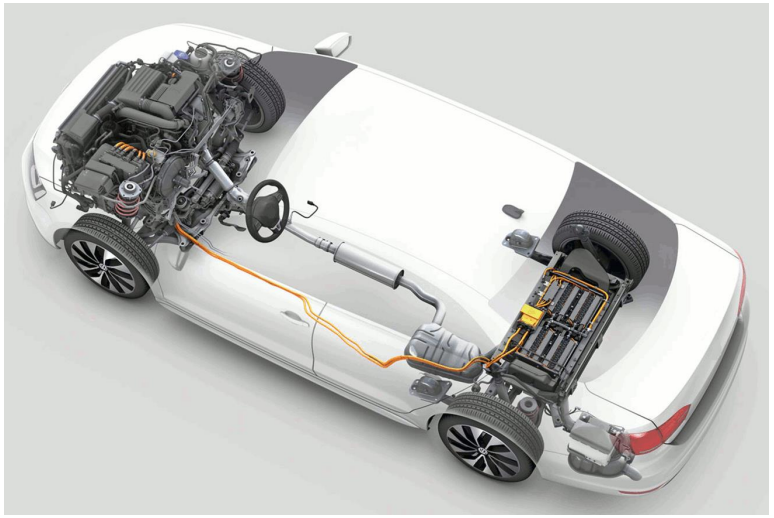


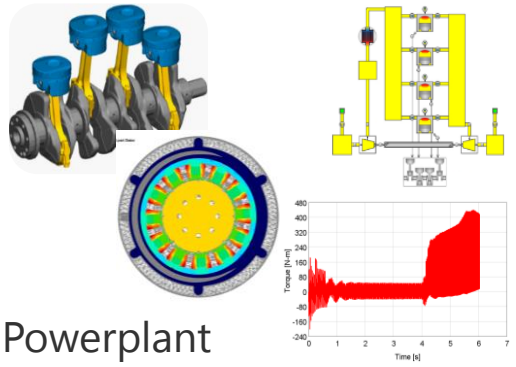
Unbalanced Block Forces

目录

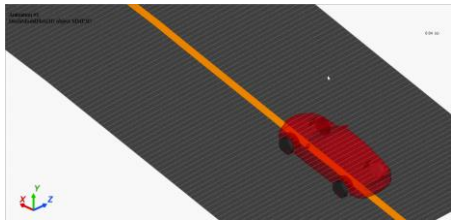
GT优势: 集成式的振动解决方案

- 将所有的子系统整合到一个模型中……在一个仿真平台上
- 预测所有详细子系统模型中的耦合
- 为大型系统模型提供了无与伦比的稳定性和速度





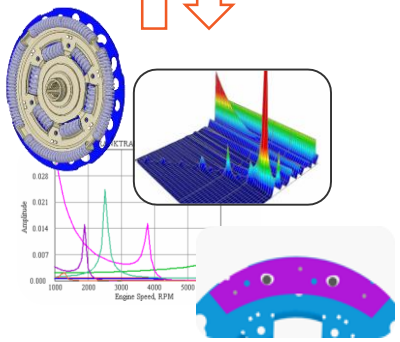
Powerplant



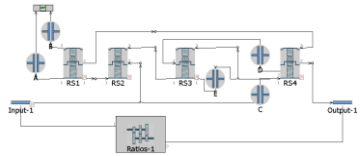
Vehicle

GT Gamma Technologies

Integrated 1D+3D CAE Solution



Torsional Dampers



Transmission

感谢倾听
期待与您合作 ☺

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