Power Electronics:

Simulation Solutions

Significant Challenges Exist To Deliver Power Electronics Technology

- Performance
- Safety
- Cost

Switching frequencies		> 20 kHz
Over-voltages		< Dielectric breakdown
Thermal reliability		< Thermal limits
System optimization		Product requirements
EMI/EMC		Meeting standards
Life		> 10 years

Multidisciplinary Power Electronics Design Requirements

Goal: An integrated, efficient multidisciplinary design workflow to increase power density and lifetime, while reducing losses, thermal derating, noise and over-voltages

Increased Collaboration; Faster Innovation; Customized Workflows; Optimization; Cloud & HPC
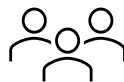
Electrical Team

System & Circuit Design

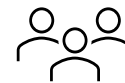Optimize system and circuit to increase efficiency

Mechanical Team

Reliability

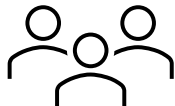Enhance PCB reliability to mitigate component failure

Software Team

Embedded Controls

Safe embedded controls to detect flaws in requirements, design and tests

Electromagnetic and Thermal Team

Magnetic Analysis

Account for magnetics to increase power density
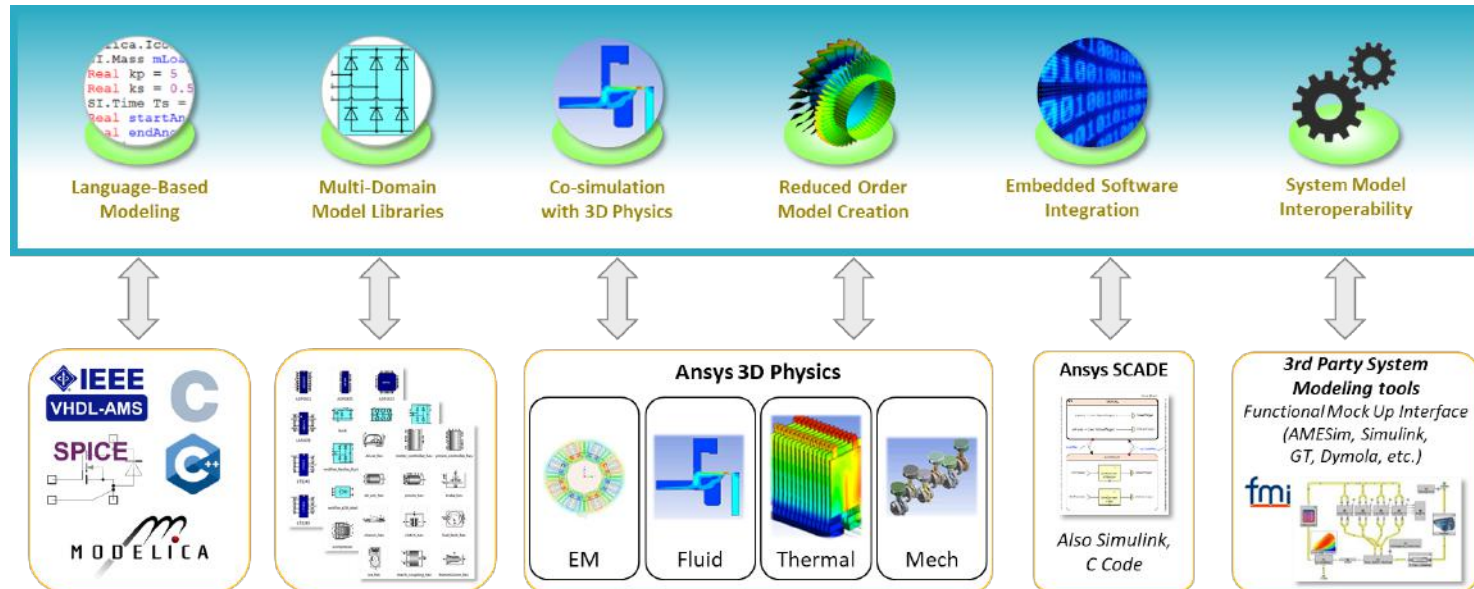
Thermal Management

Enhance thermal performance to mitigate component failure

EMI/EMC

Master EMC certification to meet standards

Optimize System and Circuit Design

Multidomain circuit and system simulation

Language-Based Modeling	Multi-Domain Model Libraries	Co-simulation with 3D Physics	Reduced Order Model Creation	Embedded Software Integration	System Model Interoperability

Ansys 3D Physics — EM, Fluid, Thermal, Mech

Ansys SCADE — Also Simulink, C Code

3rd Party System Modeling tools — Functional Mock Up Interface (AMESim, Simulink, GT, Dymola, etc.) — fmi

Customer Goal

- Enable **higher power densities** in smaller footprint
- **Increase efficiency** with higher switching frequencies
- Overcome **EMI/EMC** and **thermal issues**

Solution

- **Multidomain circuit** and **system simulation**
- Complex **system models, model libraries** and **reduced-order model workflows**
- Power device characterization at **different levels of accuracy** depending on need

Benefits

- **Enable** broader application range
- **Reduced** test cycle for EMI/EMC
- **Reduced** failures due to thermal stress
- **Increased** competitive advantage

Enhanced PCB Reliability

Customer Goal

- Mitigate **failure of electronic** components
- Meet **standard test criteria** with reduced physical prototyping

Solution

- **Lifetime prediction**
- Coupled physics simulations in a **single platform**
- Electronics **CAD** formats import capability,
- **Easy to use**
- Broad **material** and **component library**

Benefits

- **Reduce costs** associated with physical testing through virtual exploration and validation
- **Rapidly calculated** PCB-Level Time-to-Failure estimates for all components on a board

Import of **electronics CAD** formats
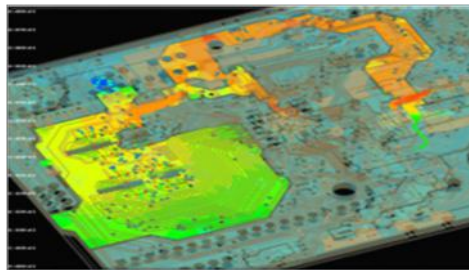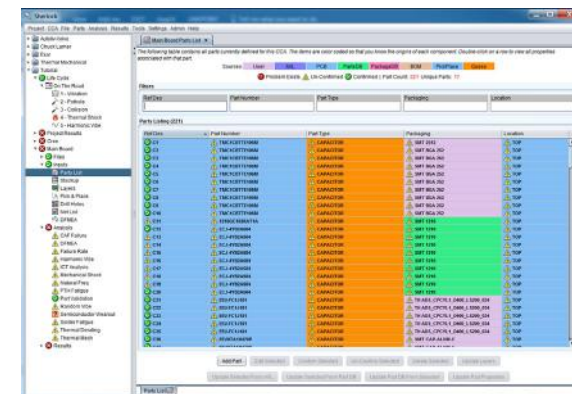

Coupled physics simulations in a **single platform**

Lifetime prediction

Material and component **library**

Safe Embedded Controls

Customer Goal

- **Virtual prototyping of hardware and software** prior to physical integration and testing

- Enable **early validation** to detect flaws in requirements, design and tests
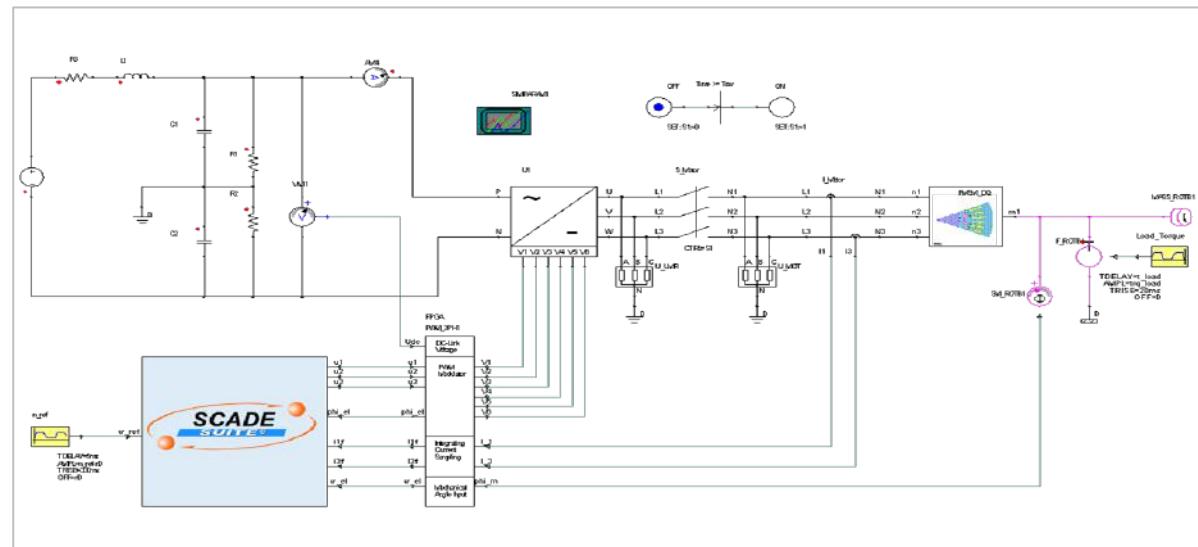
Solution

- **Flexible platform** for embedded software integration with physics-based reduced-order models and **extensive library**

- **Qualified code generation**

- System level models with ability to export and consume **FMI/FMU**

- **Flexible** and **scalable** Model Based System Engineering approach

Benefits

- **Reduced development time and cost** through seamless certification flow and early verification and validation

- **Ensured safety** of embedded software

Flexible platform with **system level models** and **FMI interface**

Account for Magnetics

Power magnetic components:

Cable   Electronics transformer

Customer Goal

- **Don't exceed temperature limits** for inductors and transformers

- Reduced size/ footprint

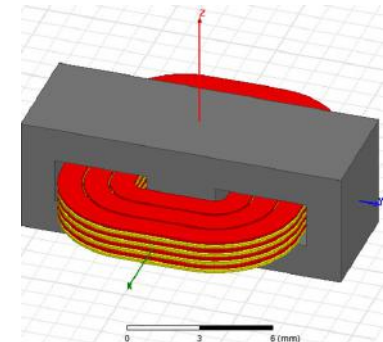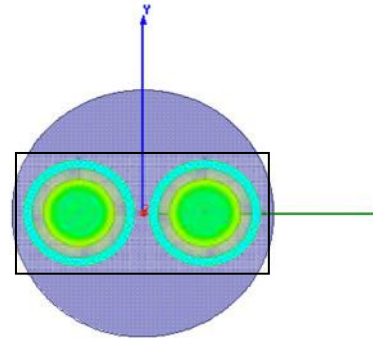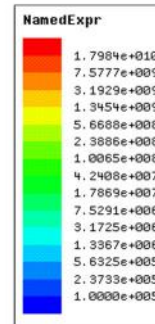- Avoid **leakage inductance**, **over voltages** and **parasitic effects**

Solution

- Models for **power magnetic components** and **electric machines**

- **Skin** and **proximity** effects consideration

- Component model coupling through **co-simulation** or **reduced-order modelling**
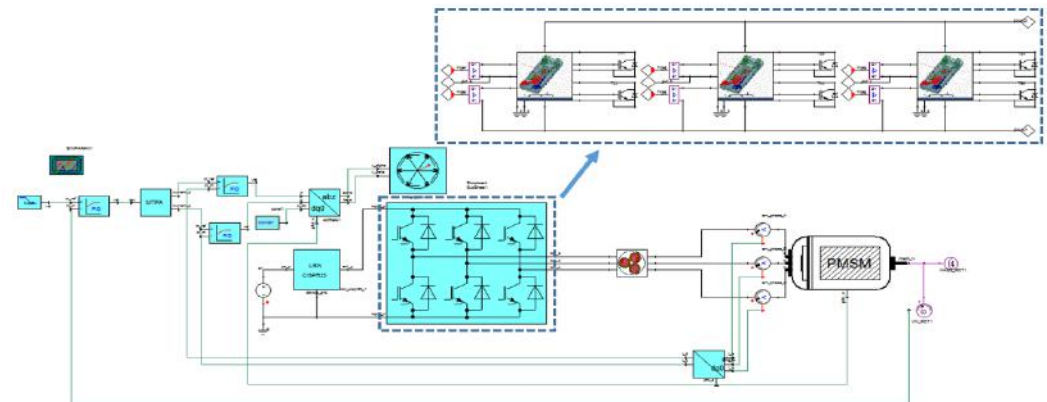
- Cover **frequency dependent parasitics**

Benefits

- **Increased** power density

- **Reduced** hot spots, operation below thermal limits

Reduced-order modelling to account for component interaction

Enhanced Thermal Performance

Customer Goal

- **Don't exceed temperature limits** for power semiconductors and enclosures
- Prevent **component failure**

Solution

- **System thermal performance** analysis with electro-thermal power semiconductor and magnetic models
- **Hot spots** and **thermal limits prediction** for bus bars and cables
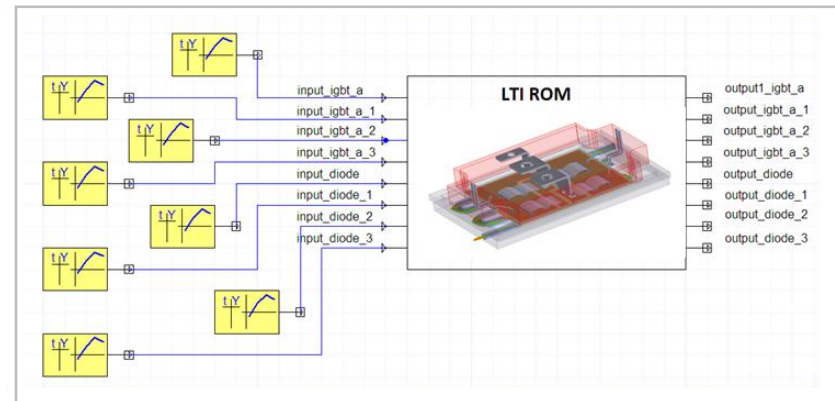- **Winding** and **core losses prediction** for magnetic components

Benefits

- **Enhanced reliability**
- **Cost-effective** thermal drive-cycle testing
- **Reduced** thermal testing

Hot spots and **thermal limits prediction**
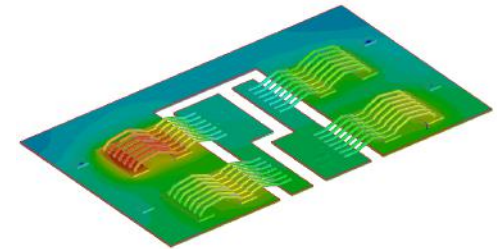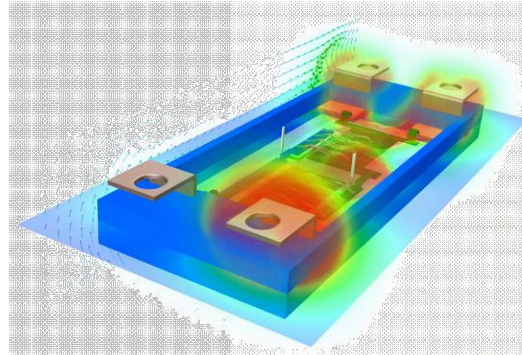
System thermal performance analysis

Master EMC Certification

Customer Goal

- Meet **required EMC standards**
- **Reduced number of re-design cycles** due to failed EMC tests

Solution

- Accurate prediction of **power semiconductor switching behavior**
- **Frequency dependent parasitics** prediction
- EMI/EMC **components library**
- **Automated** and **streamlined workflows**
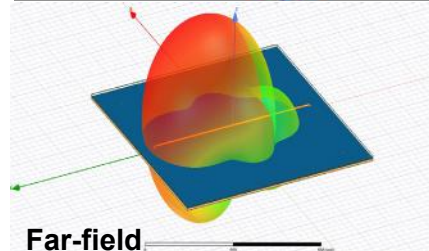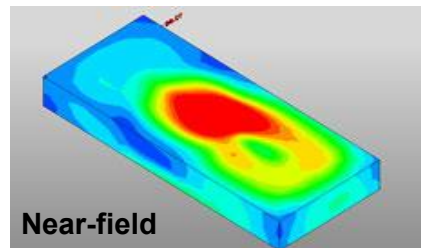- **Radiated** and **conducted noise prediction**

Benefits

- Early **detection and mitigation** of EMI/EMC effects
- **Weak point** localization that cannot be determined by measurements
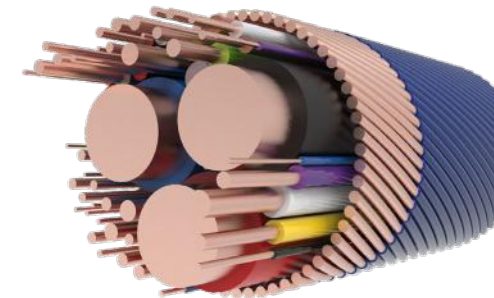- Reduced **time and costs** for tests by 20-40%

Conducted EMI/ EMC library
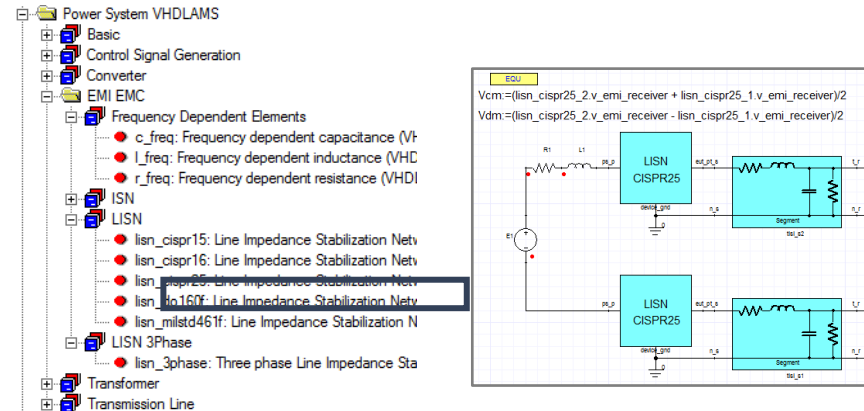
Radiated noise prediction:

Near-field

Far-field

Automated, streamlined workflows for cable analysis

Quantified Impact Of Simulation On Power Electronics

Performance

Design Cycle Time Reduction

Cost Reduction

2000x

75%

30%

Speed-up using reduced-order models[1]

Compressed PCB development time[2]

Productivity gains[3]

1. https://www.ansys.com/resource-center/article/hot-flash-ansys-advantage-v10-i1
2. https://www.ansys.com/en-in/resource-center/article/driving-down-time-to-market
3. https://www.ansys.com/en-in/resource-center/article/leading-the-electric-vehicle-charge