



Power Modules  
Packaging & Prototyping  
Reliability & Lifetime



Fraunhofer Institute for Integrated Systems and Device Technology IISB

# Device, Power Module and Power Electronic System Simulations

## Simulation for Power Electronics

vGaN-ready halfbridge power module with module-integrated driver stage © Elisabeth Iglhaut / Fraunhofer IISB

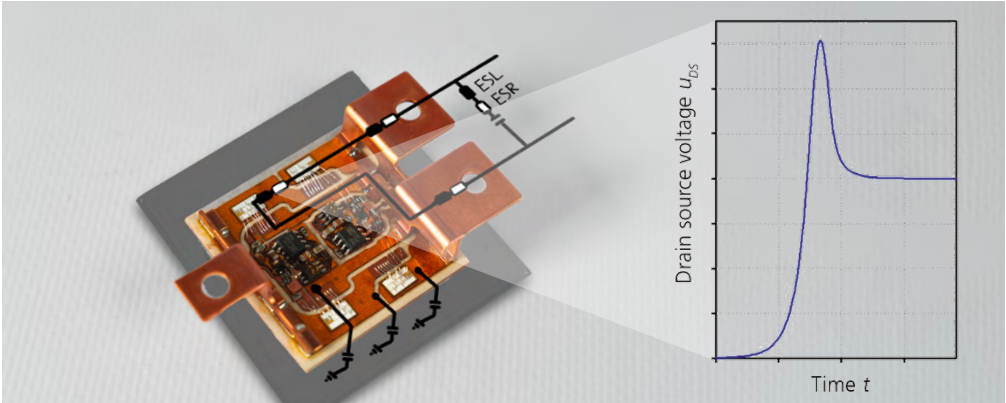
Understanding the electrical, thermal and thermo-mechanical interactions is the key to designing innovative power modules. At Fraunhofer IISB, the focus is on simulation and calculation during development as well as the coupling of the different domains, both in the area of power modules as well as for complete power electronic systems. All simulations are closely linked to the application and verified by measurements.

For each power electronics focus and application, from watts to megawatts, specific simulation tools are used. Our expertise in the field of power electronics simulation covers a wide range of applications and projects, particularly in the following areas:

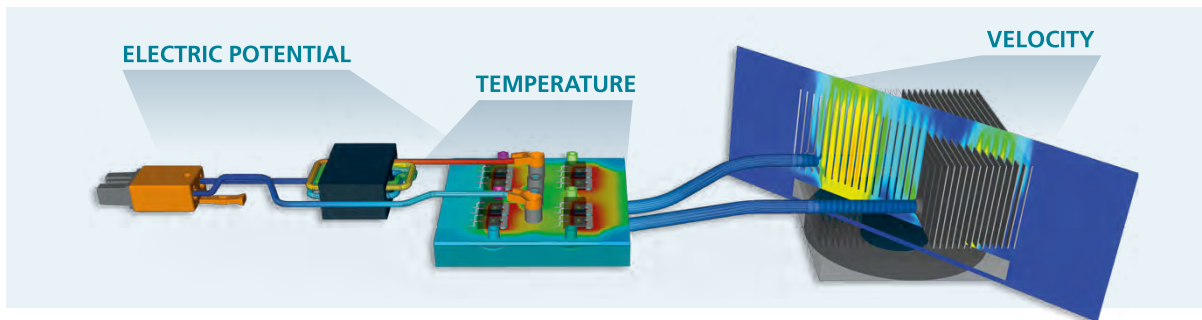
- Automotive, aviation and more
- Inverter, DCDC converter and charging applications
- Power electronics for cryogenic up to high temperature conditions

- Air cooling, liquid cooling, direct-cooling, cooling with cryogenic medias
- Single- and double sided cooling approaches, advanced cooling technologies
- Simulation-assisted power module and PCB-circuit design – electrical, thermal, thermo-mechanical
- Integration of components and embedding in power modules
- SiC, GaN, vGaN, Si
- Analysis of vibration and shock loads as well as robustness
- Lifetime analyses and modelling

### What are you challenging us to do?



Parasitic extraction (inductance, capacitance) of a power module as input parameter for circuit simulation - turn off overshoot due to the inductance © Fraunhofer IISB



Electronics simulation of Joule heating, component losses and forced convection © Fraunhofer IISB

## Power module design

- Calculation of the inductance and capacitance values of PCB or standard power module designs as well as of sensors and other similar applications
- Electric current, potential and field strength distribution analysis, Electromagnetic simulation
- Optimization and analysis of structures and arrangements via simulation
- Computation of the deformation due to temperature loads of the fabrication process or during operation
- Illustration of the internal stress of the attached materials in a stacked arrangement
- Fundamental assessment of the temperature distribution
- Identification of critical areas of the insulation due to high field strengths
- Verification of test structures by various in-house measurement possibilities, for instance static and Lock-In-Thermography, indirect thermal impedance and resistance ( $R_{th}$ ,  $Z_{th}$  / different coolants, flow rates, temperatures), etc.
- Material characterization for realistic material properties as input for simulations (for example nanoindentation, tensile tests at different temperatures)

## Cooling

- Computational fluid dynamics (multi-fluid)
- Investigation of the temperature distribution of operating electronics
- Steady-state and transient temperature behavior
- Radiation and Joule heating
- Detailed chip, board, and system level within one simulation
- Complex geometries and 3D component assemblies

## Circuit simulations

- Circuit simulation of power modules, for instance half-bridge or commutation cells
- Circuits based on designed layouts, the extracted parasitics serve as input parameters
- Realistic answers of the system to applied voltage and current wave forms
- Parasitic extraction of electronic setups – capacitance, conductance, inductance and resistance matrices

## Electric and electromagnetic simulation

- Electric field strength distribution
- Parametric studies of dependencies with respect to the field distribution
- Electromagnetic losses in high frequency applications

## Multiphysics simulation

- Multiphysics coupling of simulation
- Coupled structures via electromagnetic fields
  - Coupling of coils – contactless energy transfer
  - Inductive heating of conductive components
- Coupling of simulation software – FEM calculations linked with circuit simulation

## Software used for simulation

- Always up-to-date versions of simulation software for multiphysics and electromagnetic
- Simulation, for instance ANSYS, Maxwell, Q3D, SixSigma, Spice,...

## Contact

Dr. Hubert Rauh  
 Power Modules  
 Tel.: +49 9131 761 141  
 hubert.rauh@  
 iisb.fraunhofer.de

Fraunhofer IISB  
 Schottkystr. 10  
 91058 Erlangen  
 Germany  
 www.iisb.fraunhofer.de



vCard Hubert Rauh