



# Thermal Engineering of Power Electronic Systems Part I

21 – 22 September 2021  
Nuremberg, Germany

Thermal engineering of power electronic systems is a key to achieve high performance and reliability. The focus of the tutorial is the thermal design and validation of a power electronic inverter exemplified by a 100 kW SEMIKUBE IGBT converter equipped with additional thermal sensors. The attendees should have basic knowledge on power semiconductor devices and power electronics systems.

**Part 1:** After a review of the basic theory of heat transfer, the calculation of losses in a voltage source inverter will be explained. For selected stationary operating conditions, the expected device temperatures of the sample converter will be calculated from datasheet values. Application of online tools to facilitate this process will be demonstrated. Participants can choose between FEM simulations and equivalent thermal network calculation with LTspice™ to simulate these operating conditions. The results are compared to thermal measurements using thermocouples and an IR camera. Furthermore, a 3<sup>rd</sup> practical training group will deal with modeling of a power board with 3D CFD thermal analysis.

**Part 2:** Following a brief summary of the results of the first part, failure mechanisms, both at semiconductor and package levels will be introduced. After that, thermo-/damage-sensitive parameters will be discussed, together with theoretical background of thermal impedance measurement. A practical experiment about measurement of thermal impedance with standard laboratory equipment will end the first day. The second day will start from concrete design for reliability concepts, then aim straight at lifetime estimation, based on both power cycling and mission-profile approaches. Advanced electro-thermal and thermo-mechanical simulation will follow, and an overview about cooling systems will conclude the 2-day tutorial.

All presentations and discussions will be in English.

## Programme

Tuesday, 21 September 2021

09:30 Start of Registration

09:45 Welcome  
ECPE e.V.

10:00 Heat: Basics, Examples, Heat-Exchange – I  
Uwe Scheuermann

11:15 Coffee Break

11:30 Heat: Basics, Examples, Heat-Exchange – II  
Uwe Scheuermann

12:45 Lunch

13:45 First Steps of a Converter Design  
Arendt Wintrich

15:40 Coffee Break

16:00 Thermal Measurements I  
- basic principles and techniques  
Uwe Scheuermann

16:30 Thermal Network Simulation  
Nils Jahn

17:25 Introduction to Finite Element Simulation  
Martin Pfof

18:20 Wrap up 1<sup>st</sup> Day

18:30 End of 1<sup>st</sup> Day

19:30 Dinner

## Programme

Wednesday, 22 September 2021

08:30 Start of 2<sup>nd</sup> Day

08:30 Thermal Measurements II  
- measurement techniques  
- practical tips and possible failures  
- practical demonstration  
Thomas Heckel

09:45 Coffee Break

10:00- Practical Training: Thermal Simulations  
15:00 with three options:

Thermal Network Simulation (LTspice®)  
Nils Jahn

CFD Thermal System Simulation with Finite Element Method -  
Martin Pfof

Modeling a Power Board with 3D CFD Thermal Analysis (Simulation and Measurement)  
Andreas Simon-Kajda, David Sulyok

For organisational reason each group is limited to 15 participants.

12:30-13:30 Lunch

Inbetween coffee during group activities

15:00 Wrap up 2<sup>nd</sup> Day, Final Discussion, Feedback

15:30 End of Tutorial

Course instructors:

- Dr. Thomas Heckel, Fraunhofer IISB
- Nils Jahn, TU Dortmund University
- Prof. Martin Pfof, TU Dortmund University
- Prof. Uwe Scheuermann, Semikron Elektronik
- Andreas Simon-Kajda & David Sulyok, Siemens Industry Software
- Dr. Arendt Wintrich, Semikron Elektronik