



## **THERMAL AND RELIABILITY MODELLING OF POWER ELECTRONICS SYSTEMS**

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### **SCOPE AND BENEFITS**

Thermal management and reliability are – besides the costs – the most challenging issues in power electronics. Besides, simulation of power electronic systems and devices is a key to achieve design for reliability. In this tutorial, after a review of the basic theory of heat transfer, and loss calculation in a voltage source inverter, different thermal approaches will be discussed including equivalent thermal network calculation, finite element modelling (FEM) and computational fluid dynamics (CFD) simulations. Depending on the application, certain types of cooling are permitted which reach from natural convection to pool boiling as the most efficient cooling technique. The tutorial will address the sources of heat generation in a power electronic system as well as the basics and possibilities of heat exchange. Case studies will show typical applications for several industrial applications. The results are compared to thermal measurements using the IR camera. Lifetime modelling and simulation is also an important stage in a robust and reliable design that is based on the physics-of-failure approach i.e. appropriate models is prerequisite for lifetime simulation. Moreover, the different operational and environmental stresses which are applied during operation have to be considered (mission profiles). Details on failure mechanisms and mission profiles will highlight the correlation between thermal characteristic and reliability. The tutorial will present and discuss the state-of-the-art of thermal and reliability simulation in the field of power electronics. Application of simulation tools to analyze the correlation between thermal impedance and reliability and the impact of cooling technologies will conclude the tutorial.

### **CONTENTS**

1. Modern reliability approaches in power electronics (30 min):
  - Motivations for more reliable power electronics
  - Paradigm shifts in reliability approaches
  - Thermal analysis of power electronics systems
2. Thermal engineering in power electronics (60 min):
  - Heat: basics, heat exchange, practical examples
  - Introduction to Finite Element Analysis
3. Case studies (90 min):
  - Reliability prediction of bond wires in wind mission profiles
  - Reliability of fuses in power electronics
  - Reliability-oriented design of PV microinverter



Schedule is as follows:

**Monday, 17 September 2018 - Tutorial day (Location: RTU, Riga, Latvia)**

08:00 - 09:30	Registration for tutorial
09:30 - 11:00	Tutorial Part 1
11:00 - 11:30	Coffee break
11.30 - 13:00	Tutorial Part 2

**WHO SHOULD ATTEND**

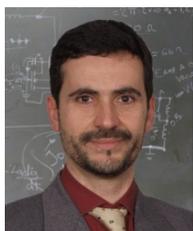
The audience is engineers or researchers in power electronics design and testing with interest in modelling and improving the reliability of power electronics. Beginners as well as experienced engineers are both welcome. Focus is more on modelling and simulation the reliability aspects from components to system level.

**Technical Level:** Advanced – The attendees should have basic knowledge on power semiconductor devices and power electronics systems.

**ABOUT THE INSTRUCTORS**



**Amir Sajjad Bahman** (M'15) is currently an Assistant Professor at the Center of Reliable Power Electronics (CORPE), Aalborg University, Denmark. His research interests include electro-thermo-mechanical modelling, packaging and reliability of power electronic systems and components. Dr. Bahman received the B.Sc. from Iran University of Science and Technology, in 2008, the M.Sc. from Chalmers University of Technology, Sweden in 2011 and the Ph.D. from Aalborg University, Denmark, in 2015 all in electrical engineering. He was a Visiting Scholar in the Department of Electrical Engineering, University of Arkansas, USA, in 2014. Moreover, he was with Danfoss Silicon Power, Germany in 2014 as the Thermal Design Engineer and with Aryacell Telecommunication Company, Iran from 2011 to 2012 as the Project Manager. He is author or co-author of more than 20 publications in journals and international conferences. He serves as peer reviewer for several conferences and journals like: APEC, ECCE, EPE, ESREF, IECON, ISIE, Elsevier Microelectronics Reliability, Journal of Thermal Engineering, IEEE Transactions on Industrial Electronics, Power Electronics and Electron Devices.



**Francesco Iannuzzo** (M'04, SM'12) is a professor of Reliable Power Electronics at the Aalborg University, Denmark, where he is also part of CORPE (Center of Reliable Power Electronics). His research interests are in the field of reliability of power devices, including cosmic rays, power device failure modelling and testing of power modules up to



MW-scale under extreme conditions, like overvoltage, overcurrent, overtemperature and short circuit. He is author or co-author of more than 160 publications on journals and international conferences and one patent. Besides publication activity, over the past years he has been invited for several technical seminars about reliability in first conferences as EPE, ECCE and APEC. Prof. Iannuzzo was the Technical Programme Committee co-Chair in two editions of ESREF, the European Symposium on Reliability of Electron devices, Failure physics and analysis, and has been appointed general chair for ESREF 2018 in Aalborg. He has been guest editor for Microelectronics Reliability and permanently serves as peer reviewer for several conferences and journals in the field, like: APEC, ECCE, EPE, ESREF, IECON, Elsevier Microelectronics Reliability, IEEE Transactions on Industrial Electronics and Transactions on Power Electronics.