TITLE

Reliability-Oriented Thermal Modelling of Power Electronics Systems

NAME AND AFFILIATION OF THE AUTHORS

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Prof. Francesco Iannuzzo (FIA), Center of Reliable Power Electronics (CORPE), Aalborg University, Denmark

SCOPE AND BENEFITS

Thermal issues plays probably the most important role in power electronics, especially for the indirect implications on reliability.
In this tutorial, after a review of the basic theory of heat transfer, and loss calculation in a power electronic circuit, different approaches will be discussed including equivalent thermal network calculation, thermal impedance extraction, and finite element modelling (FEM) to perform thermal simulations. Depending on the application, very different cooling types can be used which range from natural convection to two-phase cooling systems as the most efficient cooling technique.
Remaining useful life (RUL) modelling and simulation come right after the previous part as a direct consequence and a key step in a robust and reliable design. The different operational and environmental stressors which are present during typical operations are introduced and discussed from basics to more advanced concepts as mission-profile based simulation. Details on failure mechanisms will highlight the correlation between the thermal domain and the reliability function.
The proposed case studies will regard some typical example from industrial applications.

CONTENTS

Modern reliability approaches in power electronics (30 min):

- Motivations for more reliable power electronics
- Paradigm shifts in reliability approaches

Thermal engineering in power electronics (150 min incl. 30 min break):

- Heat: basics, heat exchange, practical examples
- Thermal impedance definition and practical implications
- Introduction to Finite-Element Analysis
- Thermal analysis of power modules
- Exercises

Case studies (30 min):

- Design and optimization of liquid cooling systems
- Modelling of thermal stress in short-circuit condition
- Thermo-mechanical simulation of future press-pack concepts

SCHEDULE

Monday, 7 September 2020 - Tutorial day (Location: INSA Lyon, LyonTech-la Doua , 20, avenue Albert Einstein – 69621 Villeurbanne CEDEX.France)

13:00 - 14:00	Registration for tutorial
14:00 - 14:30	Modern reliability approaches in power electronics (FIA)
14:30 - 15:30	Thermal engineering in power electronics – Part 1 (ASB)
15:30 - 16:00	Coffee break
16:00 - 17:00	Thermal engineering in power electronics – Part 2 (ASB)
17:00 - 17:30	Case studies (FIA)

WHO SHOULD ATTEND

The tutorial is intended for students and design engineers with interest in thermal modelling of power electronics for improved reliability. Beginners, as well as experienced engineers, are welcome to attend the tutorial. Basic knowledge of power semiconductor devices and power electronic systems is recommended, although not mandatory.

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

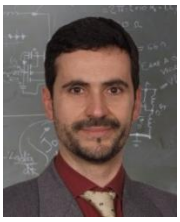
ABOUT THE INSTRUCTORS

Amir Sajjad Bahman (**IEEE M'15-SM'19**) is currently an Assistant Professor at the Center of Reliable Power Electronics (CORPE), Aalborg University, Denmark. His research interests include electro-thermal and 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 at 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. He is author or co-author of more than 50 publications in journals and international conferences. He currently serves as the Associate Editor of Elsevier Microelectronics Reliability. He also serves as the reviewer for several conferences and journals like: APEC, ECCE, EPE, ESREF, IECON, ISIE, Elsevier Microelectronics Reliability, Applied Thermal Engineering, IEEE Transactions on Industrial Electronics, Power Electronics and Electron Devices. He is the two times best paper award winner in APEC 2014 and 2017.

Dr. Bahman has been the lecturer for several workshops and tutorials about thermal engineering and reliability of power electronics in Asia, Europe and USA. He is the lecturer and instructor in the master and Ph.D./industrial courses about reliability of power electronic systems and power electronics multiphysics modelling.

Dr. Bahman has been appointed as the general chair of THERMINIC 2022 conference, in Aalborg, Denmark.



Francesco Iannuzzo (**IEEE M'04-SM'12**) received the M.Sc. degree in Electronic Engineering and the Ph.D. degree in Electronic and Information Engineering from the University of Naples, Italy, in 1997 and 2002, respectively. He is primarily specialized in power device modelling.

He is currently a professor in reliable power electronics at the Aalborg University, Denmark, where he is also part of CORPE, the Center of Reliable Power Electronics. His research interests are in the field of reliability of power devices, including mission-profile based life estimation, condition monitoring, failure modelling and testing up to MW-scale modules under extreme conditions. He is author or co-author of more than 210 publications on journals and international conferences, three book chapters and four patents.

Prof. Iannuzzo is a senior member of the IEEE (Industry Application Society, Reliability Society, Power Electronic Society, and Industrial Electronic Society). He currently serves as Associate Editor for Transactions on Industry Applications, JESTPE, and Open Journal of Power Electronics, and is Vice Chair of the IAS Power Electronic Devices and Components Committee. In 2018 he was the general chair of the 29th ESREF, the first European conference on reliability of electronics.

Prof. Iannuzzo has been appointed general chair of EPE 2023 conference, in Aalborg, Denmark.

Prof. Iannuzzo has been invited for several technical seminars about reliability in first conferences as EPE, ECCE, PCIM, ISPSD and APEC over the past years. He is the lecturer of two master courses and four Ph.D./industrial courses about reliability and design for reliability at Aalborg University.