UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

DOTTORATO DI RICERCA / PHD PROGRAM IN
INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

Ad hoc course announcement

TITLE: NUMERICAL METHODS FOR THERMAL ANALYSIS, MODELING, AND SIMULATION: APPLICATION TO ELECTRONIC DEVICES AND SYSTEMS.

LECTURER: ANTONIO PIO CATALANO, PH.D.

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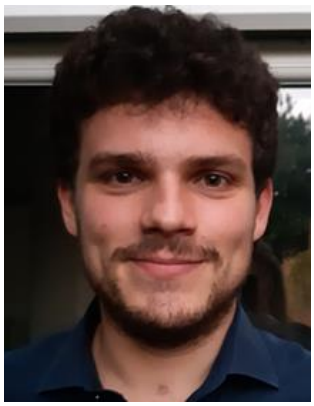

BIO NOTES: Antonio Pio Catalano is an Assistant Professor at the University of Naples Federico II since December 2021. He earned his Ph.D. in Information Technology and Electrical Engineering from the same University under the guidance of Prof. Vincenzo d'Alessandro discussing the thesis entitled "Numerical simulations and analytical modeling of the thermal and electrothermal behavior of electronic components and packages". Since 2016, Dr. Catalano's research has primarily focused on thermal and electrothermal effects in semiconductor devices. His work has led to numerous collaborations with esteemed national and international scientists, including Prof. Lorenzo Codecasa (Politecnico di Milano, Italy), Prof. Alberto Castellazzi (Kyoto University of Advanced Science, Japan), Dr. Peter J. Zampardi (Qorvo Inc., Newbury Park, California, USA), Prof. Michael Schröter (TU Dresden, Germany), Prof. Thomas H. Zimmer (Université de Bordeaux, France), and many others. Dr. Catalano authored and co-authored ~50 scientific contributions in peer-reviewed international journals, conference proceedings, book series, and book chapters. He also actively acts as a reviewer for many IEEE, Elsevier, and MDPI journals. In the context of international conferences and symposia, he has served as a technical program committee member for the IEEE ISPSD (International Symposium on Power Semiconductor Devices) and has chaired three sessions for conferences in the field of power electronics. In 2023, he was honored with the prestigious Harvey Rosten Award for Excellence in recognition of his outstanding contributions to the thermo-electrochemical modeling of Li-ion batteries.

CREDITS: 4 CFU/ECTS

OVERVIEW: Nowadays, the assessment of the dynamic temperature evolution of electronic systems – regardless of their final applications – is of utmost importance. A solid foundation in thermal analysis, modeling and simulations will be presented in this *ad hoc* course. Although electronic devices and circuits will be considered as practical case-studies, the expertise gained in the use of the presented tools can be easily adopted in alternative areas in both IT and industrial scenarios.

The primary target of this course is to guide students in correctly setting up thermal problems and extracting/exploiting key thermal metrics. The course includes a comprehensive schedule, featuring hands-on experience with commercial software for finite element method (FEM) simulations. Specifically, students will be provided with temporary licenses for COMSOL Multiphysics to conduct thermal simulations. In addition, the course covers the process of fitting thermal metrics in MATLAB and their modeling within a SPICE-like environment, offering practical insights and discussions. Examples of fully circuital electrothermal simulations in the SPICE-like software will also be presented.

There will be a final assessment, in which students will be required to present how they can effectively apply the course material to a case study falling within their own research areas.

SCHEDULE:

Lecture	Date	Time	Topics	Lecturer
1	26/01/2024	14.30-17.30	Introduction to thermal analysis	A. P. Catalano
2	30/01/2024	14.30-17.30	FEM simulations with COMSOL – Part I	A. P. Catalano
3	02/02/2024	14.30-17.30	FEM simulations with COMSOL – Part II	A. P. Catalano
4	06/02/2024	14.30-17.30	Circuital thermal modeling	A. P. Catalano
5	09/02/2024	14.30-17.30	Simulation in circuital solver. Overview of electrothermal modeling	A. P. Catalano
			Assessment test	

CONTENTS:

Lecture 1 – The fundamental concepts of thermal analysis will be presented. As a *mere* case study, an assembly embedding electronic devices will be adopted. Key thermal parameters as thermal resistance (R_{TH}), mutual (coupling) thermal resistance (R_{THM}), and thermal impedance (Z_{TH}) will be introduced and discussed. A brief overview of nonlinear thermal effects induced by the temperature dependence of the thermal conductivities will be given.

Lecture 2 – Once the foundational concepts are established, the thermal analysis in a finite-element method (FEM) environment using COMSOL Multiphysics will be explored. Students will take part of a practical session, where they will learn how to (i) build a 3-D geometry, (ii) define an efficient mesh, and (iii) set up thermal simulations on their personal computers.

Lecture 3 – Students will receive detailed instructions on how to perform static and dynamic thermal simulations within COMSOL Multiphysics. Over an hour will be dedicated to guide students in obtaining thermal metrics for the structure they construct on their personal computers. The procedure to evaluate heating dictated by a source on an arbitrary (sensing) point/region of the domain will be also illustrated.

Lecture 4 – Focus will be given to the fundamentals of circuital thermal modeling. The lecture will delve into the evaluation of Cauer-like thermal networks and the extraction of Foster-like thermal networks. Specifically, the fitting of thermal impedance in a MATLAB environment will be demonstrated and implemented.

Lecture 5 – The practical implementation of equivalent thermal networks in circuital SPICE-like environments will be presented. The primary objective is to assess temperature profiles over time in an efficient and accurate way. Additionally, practical examples of electrothermal modeling within the same circuit framework will be provided.

The lectures are held in T3 room, ground floor of building #1, via Claudio 21, Napoli.

Participants are requested to join the following MS Teams group:
https://teams.microsoft.com/l/team/19%3axwFfkhsoHPYQRml7veTZA6f3LoLQ6SsMTDVacZ3bpNk1%40thread.tacv2/conversations?groupId=d8039eb2-d115-4ece-a4e4-9f7bc850f230&tenantId=2fcfe26a-bb62-46b0-b1e3-28f9da0c45fd

Once accepted in the Teams group, students have to fill the following .xlsx file with their information:
https://communitystudentiunina.sharepoint.com/:x:/s/AD-HOCCOURSEITEE-NUMERICALMETHODSFORTHERMALANALYSISMODELINGA/ESYq7ABYXm5Ph6Dc_IevTbUB0_-0M3vpFeUL3qhhOVdslA?e=1WTrcv

The course is conducted on-site. However, students pursuing their PhD period abroad (for research purposes) have the option to request remote attendance for classes via MS Teams.

For information: Dr. Antonio Pio Catalano (DIETI, UniNA) – antoniopio.catalano@unina.it *(lecturer)*