

# COMPUTER AND CONTROL ENGINEERING

## MUR DM 117/STMicroelectronics - Design Automation for Mixed-Signal Heterogeneous Systems

<b>Funded By</b>	MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] STMICROELECTRONICS S.R.L. [P.iva/CF:00951900968] Politecnico di TORINO [P.iva/CF:00518460019]
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<b>Context of the research activity</b>	<p>The thesis will explore modern design automation techniques aimed at improving productivity in the design of mixed-signal system-on-chip platforms, such as those used in smart sensors for the Artificial Intelligence of Things (AIoT). ST Microelectronics, a world-leader in this field, will indicate the most relevant research problems, giving the candidate the unique opportunity to integrate its work with industrial design flows and products.</p> <p>Progetto finanziato nell'ambito del PNRR - DM 117/2023 - CUP E14D23002020004</p>
	<p>The thesis, co-funded by ST Microelectronics S.r.l., will explore modern design automation techniques for mixed-signal system-on-chip platforms, such as those used in smart sensor devices for the Artificial Intelligence of Things (AIoT). These systems are increasingly complex and include many heterogeneous digital and analog components. Therefore, enhancing productivity in their design process requires automation throughout the software and hardware stack, from the application-level down to the device-level.</p> <p>On the hardware design side, the candidate will explore the use of both rule-based and data-driven graph algorithms for analyzing mixed-signal circuits, e.g., quantifying the amount of novelty in each design iteration, or finding graph topologies that require specific constraints during place and route.</p> <p>For what concerns software, advanced compilation and mapping algorithms will be explored to optimize the execution of relevant applications, such as neural network inference, on the general purpose and domain-specific digital hardware blocks present on the system.</p>

## Objectives

The work plan of the project will be structured as follows:

Months 1-9: Conduct an extensive study and literature review on state-of-the-art on i) Mixed-signal design, ii) Electronic Design Automation (EDA) techniques and iii) Advanced low-level compilation and mapping for heterogeneous systems, to become familiar with the context of the thesis. The candidate will have the chance to learn the differences in terms of algorithms and level and maturity between digital and analog EDA, and the unique issues associated with deploying complex software on these highly constrained platforms.

Months 9-24: Implement and test state-of-the-art new state-of-the-art EDA techniques (HW Level) and software-optimization techniques (SW Level) for Mixed-signal systems, focusing on increasingly complex benchmark circuits and applications, respectively. Specifically, the candidate will apply both classic graph-based algorithms and machine learning techniques (e.g., Graph Neural Networks) to the analysis and optimization of mixed-signal circuits. In parallel, advanced software compilation and optimization tools will be developed to map complex applications (e.g., neural network inference) on the digital compute blocks of the device.

Months 24-36: Deploy and evaluate the newly developed techniques on highly complex systems, comparable to those put on the market by ST Microelectronics. This phase will constitute the final benchmark for the scalability and effectiveness of the developed methods.

The candidate will also have the unique opportunity to test the developed techniques on custom ASIC testchips and/or FPGA-based prototyping platforms.

Possible publication venues for this thesis include:

- IEEE Transactions on CAD
- IEEE Transactions on Circuits and Systems (I and II)
- IEEE Transactions on Computers
- IEEE Transactions on Emerging Topics in Computing
- ACM Transactions on Embedded Computing Systems
- ACM Transactions of Design Automation of Electronic Systems
- Design Automation and Test in Europe (DATE) and Design Automation Conference (DAC)
- etc.

On the topics of this thesis, the EDA Group at Politecnico di Torino coordinates a Marie Curie Research and Innovation Staff Exchange (RISE) project called AMBEATion, in collaboration with two world-leader industries in microelectronic design (ST Micro) and EDA (Synopsys) and two other universities (University of Prague and University of Catania). Furthermore, the group has several other industrial collaborations and funded projects on these topics, including:

- TRISTAN (ECSEL-JU 2023)
- ISOLDE (ECSEL-JU 2023)
- StorAlge (ESCEL-JU 2021)
- Etc.

## Skills and

1. Good programming experience in languages such as Python and C is needed (must have).

**Skills and competencies for the development of the activity**

2. At least a basic knowledge of digital and analog circuits is preferable.
3. A basic understanding of (digital) EDA is also a plus. Otherwise, this understanding will have to be acquired during the initial study and literature review phase.
4. A basic understanding of embedded systems and computer architectures is necessary for the software optimization part of the work.