ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

CRT/DENERG – AI-driven Design of High Performance, 3D Power Electronics

Funded By	Dipartimento DENERG FONDAZIONE CRT CASSA DI RISPARMIO DI TORINO [P.iva/CF:06655250014]
Supervisor	BOJOI IUSTIN RADU - radu.bojoi@polito.it
Contact	MANDRILE FABIO - fabio.mandrile@polito.it
Context of the research activity	Power electronics is an enabling technology for strategic applications, such as electrification for energy transition, including the transports (air, land, sea), smart grid integration of renewables and high efficient industrial applications. Traditional power electronics design is often: (1) 2D and modular (separate device, package, and thermal design), (2) Manual and iterative, relying heavily on expert intuition, (3) Limited by parasitics, thermal bottlenecks, and (4) Required to fulfill constraints, such as size, cost, mass and volume. The 3D Power Electronics enables the best vertical integration of power devices, magnetics, and cooling, with short electrical paths to minimize the parasitics, while providing the best volumetric power density at the best efficiency possible, depending on the selected technology for the power devices. The challenges of 3D power electronics cannot be solved with the conventional design approaches, due to its multi-physics and multi-scale nature. Moreover, 3D power electronics are computationally expensive to explore manually. The PhD project aims at developing advanced tools and design methodology of power electronics, with the support of Artificial Intelligence (AI) to get the optimal converter solution. The final converter design includes the tri-dimensional (3D) layout for all converter elements: power devices, reactive parts (magnetics and capacitors), cooling, control board, sensors, EMI filter and outer case.
	The PhD research project objectives are: • Develop an AI-driven design methodology for power electronic converters, based on modular libraries of components. • Integrate physics-informed learning (PINNs) and graph neural networks (GNNs) to embed physical consistency and component connectivity directly into the generative model.

Objectives	• Train AI models for 3D converter generation, exploiting Generative AI architectures (e.g., diffusion models, variational autoencoders, or transformer-based 3D generators) to synthesize realistic converter layouts that satisfy electrical, thermal, and mechanical constraints. • Selection of the best candidate of the converter design • Prototype and testing of ultra-high power density GaN power electronic converter for high performance applications.

Skills and competencies for the development of the activity	• Master Degree in Electrical Engineering • Good knowledge of power electronics and control solutions for power conversion • Good knowledge of simulation environments for power electronics (Plecs, Pspice) • Good knowledge of real time control and software for finite element analysis for electrical circuits (Ansys Q3D, Python, Matlab/Simulink) The candidate must demonstrate very good capability in facing new challenges and must be very motivated in reaching the research objectives.