ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

DENERG - Power dense fault-tolerant electrical machines for safety critical and lightweight propulsion and generation applications

Funded By	Dipartimento DENERG
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Context of the research activity	The research activity aims to identify viable solutions and design criteria for highly efficient and fault tolerant ac electrical machines having enhanced power density values achievable exploiting superconducting materials.
Objectives	The research activity conducted by the PhD student will take place in the context of cutting-edge studies towards the development of power dense electrical machines for a next generation of high performance, lightweight, sustainable and reliable propulsion and generating systems. In particular, the activities will be developed in the framework of the National Research Projects entitled “Superconducting electric machines and crYogenic power electronics for high-efficiency, reliable and power-dense eNERGY conversion (SYNERGY) - Prot. 2022H78JBT” and “Multi-phase fault tolerant MW range generation systems for hybrid-electric aircrafts - Prot. 2022H9LJKC”. Besides high efficiency values, the power-to-weight ratio represents a key performance index to minimize the environmental footprint of energy conversion devices as well as their practicability for applications like aircraft electric propulsion-generating systems. Moreover, the limited use of permanent magnets as well as the fault tolerant capability are of paramount importance for such applications. To achieve the challenging performance values imposed by the abovementioned targets, the design of electrical machines must have a paradigm shift towards design solutions that encompass unconventional operating conditions and materials, such as cryogenic temperatures or the use of superconductors. In this context, the studies conducted by the PhD candidate will contribute to the development of scientific knowledge investigating viable cryogenic electrical machine solutions that avoid the use of permanent magnets, such as ac electrically excited machines with superconducting windings excitation to achieve high power density values. For enhanced fault-tolerant capabilities, different configurations of multiphase stator winding layouts will be investigated. Within the PhD activities, the candidate will identify the design criteria and will

	develop multiphysics simulation methodologies to consider the non-conventional behavior of the materials when operated at the cryogenic temperatures. The developed design and simulation tools will be calibrated and validated by means of tests on both superconductors as well as on conventional ferromagnetic materials at cryogenic temperatures. Simulations for MW range electrical machines will be conducted to pave the way for the development of the future propulsion and generating technologies for transportation and renewable systems. The PhD candidate will be required to disseminate the achieved research results in highly recognized international conference and journals.

Skills and competencies for the development of the activity	The candidate is required to have good knowledge of the electromagnetic phenomena at the base of the electromechanical conversion as well as an enhanced attitude to experimental calibration and validation of the developed design tools is a preferential element.