ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

DM 630/Centro Ricerche Fiat - Design and test of high speed EESMs for traction applications

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Context of the research activity	Innovative and sustainable electric motor solutions for the drivetrains of battery and fuel-cell electric vehicles. Progetto finanziato dal PNRR a valere sul DM 630/2024 - CUP E14D24002420004
Objectives	Permanent Magnet Synchronous Machines (PMSMs) are used in traction applications due to their superior torque and power density, primarily resulting from high-energy permanent magnets composed of rare-earth elements (REEs), such as sintered NdFeB alloys. The concentrated supply of REEs in a few countries raises concerns about cost volatility and environmental impact. To mitigate REE dependence, engineers are exploring higher operating speeds for PMSMs, decreasing the torque rating and thus the volume of iron, copper, and REE-based magnets while maintaining power output. The target for traction PMSMs is now 30,000 rpm. Electrically Excited Synchronous Machines (EESMs) offer a REE-free alternative, replacing permanent magnets with a DC-excited rotor coil. Although eliminating REE reliance, achieving speeds beyond 16,000 rpm poses challenges related to rotor structural integrity and high-speed exciter feasibility. Overcoming these obstacles could lead to high-power density EESMs without REEs, aligning with the automotive industry's sustainability goals. This PhD research focuses on developing a new generation of High-Speed EESMs for traction applications. Key objectives include: - proving the high-speed objective feasible, the two main challenges being

	the rotor integrity and the rotor excitation system. - improve the thermal management, which is very critical in compact high-speed motors also requiring dedicated rotor cooling. Direct oil cooling is the current best standard, and customized solutions are required for the stator and rotor cooling of HS-EESMs. - Formulate and test a dedicated control and simulation model using multiple flux maps, including the procedures for the experimental evaluation of the said model. The candidate will be part of a multidisciplinary team of experts in e-motor design, mechanical engineering, and power electronics at the Power Electronics Innovation Center (PEIC) of PoliTo. Stellantis will provide input, tutoring and hospitality for the secondment periods.

Skills and competencies for the development of the activity	The ideal candidate should possess a strong background in electrical engineering, particularly in electrical machines and electric motor drives. Student-level experience in experimental testing of electrical machines and drives and a willingness to deepen this skill and gain autonomy in the laboratory are essential. The candidate should also demonstrate teamwork and problem-solving abilities within a multidisciplinary environment.