Doctoral Student Programme
Geneva, Switzerland
Full-time

Thesis (PhD)

Failure Modes and Condition Monitoring of IGBTs in Pulsed Applications

General Context

At CERN, the European Organization for Nuclear Research, physicists and engineers are probing the fundamental structure of the universe. Using the world's largest and most complex scientific instruments, they study the basic constituents of matter - fundamental particles that are made to collide together at close to the speed of light. The process gives physicists clues about how particles interact, and provides insights into the fundamental laws of nature. Find out more on http://home.cern.

Power electronic converters are a building block of CERN's cutting-edge particle accelerator systems and, thus, a fundamental to support the forefront of science. The Electrical Power Converter (EPC) group at CERN oversees the design, development, procurement, construction installation, operation, and maintenance of electrical power systems for all accelerators, transfer lines, experimental areas, and test facilities.

While Power Converters have already several applications in different fields, the requirements of CERN systems differ from what is usually found elsewhere in terms of reliability, precision, and robustness, all important pillars to support CERN activities and experiments.

Job Description

This PhD position is offered in relation to the use of power semiconductors within the Proton-Synchrotron (PS) and Booster accelerators at CERN. More specifically, the power semiconductors applied in the power electronics converter systems used to control the magnetic field in the dipole magnets of these accelerators.

Due to the controllability and operational requirements of these converter systems, these units were designed and implemented based on press-pack IGBT's (insulated gate bipolar transistors) technology.

Differently than most applications worldwide in which press-pack IGBTs are applied, these units at CERN experience very specific stresses during their lifetime. Not only an uninterrupted operation is expected from these systems for 10 out of 12 months a year, but

also the type of operation imposed by the Booster and PS accelerators results in these units experiencing about 3 to 4 million thermal cycles during a calendar year.

While the degradation and ageing mechanisms of other IGBT module packaging technologies are nowadays well-understood, the same cannot be stated for press-pack IGBTs. Moreover, it is to be expected that degradation and/or ageing mechanisms in press-pack IGBTs differ from other packaging technologies due to their inherent distinctive assembling characteristics as well as materials used.

As part of the POPS+ project, a new testing platform is to be developed to allow for the investigation of press-pack IGBT degradation/ageing mechanisms related to the specific stresses that such units are expected to undergo while in operation at the CERN.

The PhD candidate will be involved in all these activities and is as well expected to:

- Contribute with thorough research on the state-of-the-art degradation and ageing mechanisms of IGBTs as well as their assessing/monitoring techniques;
- Contribute to the design, set up and operation of the CERN testbed for press-pack IGBT ageing and degradation assessment;
- Analyze measured and gained data out of the aforementioned CERN testbed as well as existing available data from CERN accelerators;
- Contribute to the detailed description of degradation and failure mechanisms of press-pack IGBTs in CERN-like applications;
- Challenge and verify existing lifetime prediction models with the aforementioned data;
- Contribute with improvements in lifetime prediction models for press-pack IGBTs, if need identified.
- All these contributions are expected to be of great value to the CERN EPC team responsible for maintaining existing power converters for particle accelerators, but also designing future ones.

PhD Candidate Profile

The candidate is required to have an excellent academic background in Electrical Engineering, Energy Engineering, or any other related discipline with skills in Power Electronics Systems and:

- Motivation and potential for research activities including ability to work independently and in a team.
- Be innovative and creative and keep open mind.
- Expertise with engineering tools and simulation software both for power electronics and data science.
- Written and oral communication in English. French would be a plus.

Take part in CERN's Doctoral Student Programme!

If you are interested, please, apply to the **Doctoral Student Programme** **no later than November 6th, 2023** at **https://careers.cern/**

I you have any questions, please send an e-mail to
aramis.schwanka.trevisan@cern.ch